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THE RESPONSE OF PLANTS TO CLIMATE

F. W. WENT

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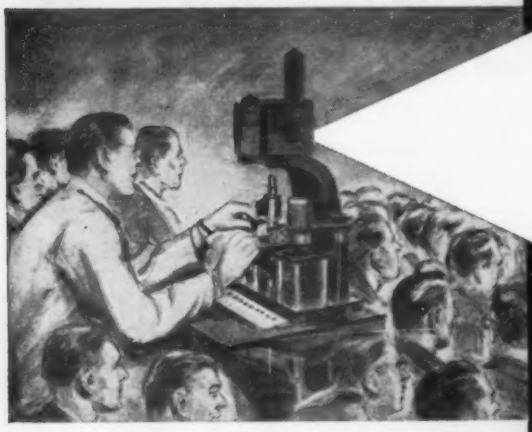

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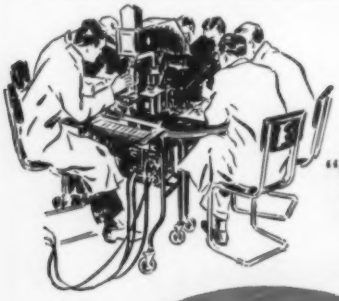

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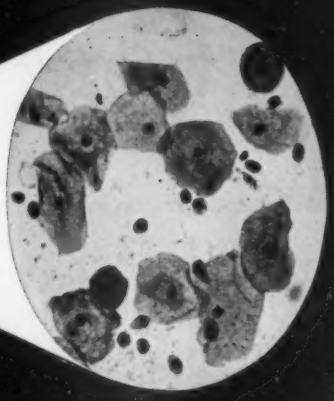

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The Response of Plants to Climate

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SOME of the most important problems in biological research are the variability of the experimental material and the control of growing conditions. These two problems are really closely related, because greater reproducibility of the environment usually results in greater uniformity.

We are so used to differences in size and form among plants which presumably should be similar because of genetic similarity, that we take these differences for granted. That probably explains why, in general, more efforts are made to cope with the variability than to reduce it. Mathematicians have devised methods to measure variability by means of statistics, and they have made rules about experimental design that randomize errors, which thus get more evenly distributed over the experiment.

A closer consideration shows that this statistical approach is illogical. Actually, the basic purity of biological material is greater than that of pure chemicals. A chemical that has less than 0.1 per cent impurity in it would, by most of us, be considered much purer and more uniform than a planting of tomatoes or peas. In reality that is not the case. The 0.1 per cent impurity in sucrose may, for instance, be NaCl, which would compare with one corn seed per 1,000 tomato seeds. It is obvious that this type of impurity does not normally lead to errors and can easily be avoided. The impurity in the tomato seed will, for the most part, be connected with deviations in the genetic make-up of some individual plant. It may be that, in genetically uniform material, one seed in 1,000 carries a different gene for leaf shape or fruit color. Yet in all other characters such an abnormal seed would be the same as the others. If we assume that there are 1,000 genes in which one tomato may differ from another, this just means that the purity is 999,999 : 1,000,000. This is a purity not existing in chemicals. An impurity of this type may be compared with one per thousand sucrose molecules containing a deuterium atom instead of a hydrogen atom in a particular location, or with one molecule of maltose instead of sucrose.

All this simply means that the variability of genetically well-selected biological material does not lie in the basic purity of the material, which is superior to almost anything we are acquainted with in physics or chemistry. There are, then, two possible explanations of biological variability. One is that the environmental conditions are so variable that the basic uniformity of the seeds cannot express itself. The other is that it is impossible to transform the potential uniformity of the seed or fertilized egg cell into uniformity in the mature organism. The latter possibility is based on the assumption that the master reactions for development depend on so few molecules that the uncertainty principle holds. Actually this means that, when a certain gene, consisting of two or very few molecules, influences growth directly, the effect will be strongly modified by chance because of the small number of reacting molecules. Thus individual variability would be a corollary of gene-controlled development, and beyond experimental control.

On the other hand, growing conditions for plants have been far from uniform and controlled, so that at least part of the bothersome individual variability of plants within a single strain could be attributed to differences from pot to pot in the degree of packing of the soil, water content, or in position of the pot in relation to light, heat source, air currents, etc. The growing of plants in sand or gravel, regularly watered with a nutrient solution containing all necessary minerals, reduces the variability of the root environment, and plants grown in this manner are considerably more uniform in size and shape.

Whereas the root environment of the plant can be controlled to a considerable extent, control is much more difficult for the parts aboveground. To maintain a constant temperature in stems and leaves, the air temperature has to be controlled, which is simple when the air is damp and light is absent. As soon as heat or light radiation hits the leaf, its temperature tends to increase. Since strong radiation is essential for plant growth, heat must be removed from the leaf during the daily light period, either by radiation or by diffusion of heat toward the surrounding air. Only the latter method is practicable, but it is fraught with many difficulties. Since the specific heat of air is low, large quantities of air have to be moved past the plant

FIG. 1. Peas develop at a uniform rate when grown in air-conditioned and artificially lighted rooms.

parts to be cooled when they are exposed to sunlight.

By the application of these basic principles the plant environment can be controlled. Control has been accomplished in several commercial greenhouses and in a few research greenhouses. It actually has been found that, under such controlled conditions, individual variability among plants is enormously reduced, because the essential purity of the genetically homogeneous seed material is translated into uniformity of the plants grown from the seeds.

Fig. 1 demonstrates the uniformity of peas grown in air-conditioned and artificially lighted rooms. All plants of the same age have grown to the same size; all stems up to the first leaves have approximately the same length; the length of the stem between first and second leaves is the same, etc. Thus the leaves seem placed in tiers. No plants were removed from the containers to take this picture, which proves that the phenotypic variability usually encountered in growing plants, even when they are genetically uniform, has no deep theoretical meaning but is due to uncontrolled growing conditions. Therefore, the significance of the uncertainty principle in biology is not as great as sometimes supposed.

The most complete air-conditioned laboratory that uses these principles is the Earhart Plant Research Laboratory at the California Institute of Technology (Fig. 2), which has been in operation since July 1, 1949. Built and equipped with a gift of $407,000 from the Earhart Foundation, of Ann Arbor, Michigan, it was the outgrowth of two small experimental greenhouses, built in 1939 at the California Institute of Technology through the initiative of Dr. H. O. Eversole. It comprises these first two greenhouses and, in addition, four larger air-conditioned greenhouses, in which temperature and humidity can be controlled within relatively narrow limits. For complete control of light, as well as temperature, there are thirteen rooms with artificial light panels producing as high as 2,000 ft-c light intensity. The panels can

FIG. 2. Earhart Plant Research Laboratory.

be switched on and off with time clocks and can be separated by curtains, so as to produce any photoperiods required. Each of the thirteen rooms has its own air-conditioning system, which keeps the temperature of each room within one-half degree of the set temperature. To insure good distribution of air throughout the greenhouses and laboratories without causing excessive drafts, a new method of air introduction was used. The air, after leaving the air conditioner, is blown into a space under the greenhouse floor, which consists of 4-inch wide steel channel beams, placed side by side with three-eighth-inch spaces between them. The air is forced up between the steel beams, mixing immediately with the greenhouse air as it moves upward past all objects in the greenhouse, absorbing the heat produced by light rays that strike all solid surfaces. The air, which is thus heated about 4° C in the middle of the day, is drawn out of the greenhouse through ducts in the side walls, and is either ejected or reconditioned. Plants are grown on movable tables, which can be wheeled from greenhouse to laboratory or darkroom. In this way all combinations among the different conditions can be made. For instance, groups of plants are kept from 8:00 A.M. till 4:00 P.M. in four different temperatures in full daylight and at nine different temperatures in artificial light. During the remainder of the twenty-four hours they are kept at any of nine different night temperatures; or they receive extra light during part or all of the night. Thus, a considerable number of independent variables can be studied simultaneously, and the interaction of their effects can be established.

Simultaneous study of a number of variables is more important than appears superficially. In the first place, there is a theoretical reason. The response of a plant to a particular environmental factor, like temperature, is very complex. Practically all its processes are influenced, and to different degrees. For example, the effect of light will differ according to how the leaf surface or chlorophyll content is affected by temperature. At present the degree of interaction of these factors cannot be predicted, and this is one of the problems that will have to be solved in this new laboratory.

In the second place, the study of the interaction of different climatic factors is important from the standpoint of practical application. In the field a plant is never subjected to a single variable. Usually, high light intensities are correlated with high temperatures and low humidities. Therefore, the practical grower must know not merely how temperature affects his crop, but how it does so at different light intensities, at different ages of the plants, and at different photoperiods. The reason plant physiology is not as basic a discipline for the practical plant sciences as one would expect on purely logical grounds probably lies in the methods heretofore used. The experimental setup did not permit the study of the interactions of various factors, because usually only one factor at a time could be varied. Where more factors could be controlled simultaneously, more progress was made. A good example of this is in the field of mineral nutrition, where different mineral elements could be varied independently, giving agriculture a satisfactory insight into the interactions between nitrate and phosphate nutrition, for example.

Fortunately, not all possible climatic variables are equally important in the development of a plant. Therefore, in a study of a plant's climatic responses, the interaction of only a limited number of variables needs to be taken into account. Let us consider the tomato plant as an example. This plant is particularly sensitive to differences in night temperature, whereas the day temperature may vary within wider ranges without affecting its response. But the night temperature response is dependent upon (1) the age or, rather, the size of the plant, (2) the previous night temperatures, (3) the light intensity on the previous two days, and (4) the variety. Such complex temperature responses are not restricted to the tomato in particular or to plants in general. In human beings we find something similar. There is not just one temperature at which a person feels most comfortable. The optimal room temperature is lower as the relative humidity rises, or as the rate of air movement decreases. It also is lower as the outdoor temperature is lower, and it depends on the degree of activity of the person and on radiation.

With respect to the tomato plant, it was found that the night temperature controls the rate of stem growth. In the young seedlings most rapid growth occurs at 26°–30° C. As the plant grows older the optimal night temperature gradually drops to lower temperatures, passing through 23° and 20°, and finally reaching optimal temperatures of 13°–18° C, depending upon the variety. Varieties developed in the Central Valley of California exhibit the highest optimal temperature; the lowest optima are found in English and greenhouse varieties. For fruit set the same rules hold. That is, the night temperature completely regulates fruit set, the first fruits being formed at higher temperatures, with the optimum gradually shifting toward lower temperatures as the plant grows older and taller, but generally being near 17° C, regardless of light intensity (Fig. 3). However, when the latter has dropped below 1,000 ft-c, no fruit set is possible at any temperature. With low day temperatures the optimal night temperature for fruit growth is higher but remains essentially unchanged

FIG. 3. Tomato plants in air-conditioned greenhouse. Plants at left show good fruit set, because they are exposed to optimal night temperature (17° C); those at right were kept at 30° C during night (no fruiting). Notice slots in floor through which air enters greenhouse, and registers in rear wall through which air returns to air conditioner.

for vegetative growth. With light intensities below 1,000 ft-c, the optimal night temperature for stem elongation gradually decreases with light intensity.

We do not have enough data as yet to express these relationships in mathematical form, but, to give an idea how the formula for the optimal night temperature for stem elongation of a tomato plant might look, the following notation is given:

Optimal night temperature $= a + b\ (c - \log l)$.

Here l means the length of the stem in cm, a, b, and c being constants. For several varieties these constants would be about:

	Tomatoes		Chili Pepper
	San José Canner	Essex Wonder	Californian
a	20	16	8
b	10	10	20
c	2	2	1.9

There are other terms to be introduced for light intensity (below 1,000 ft-c) and perhaps for day temperature.

The temperature relationships of the tomato plant can also be expressed by plotting its optimal growing conditions at maturity, when the second term in the formula above for optimal night temperature has become constant at lengths of more than 1 m. We can then indicate the climatic response of the tomato in terms of the three most important climatic variables that cannot easily be changed by cultural treatments, namely, day temperature, night temperature, and length of day. In Fig. 4 this is attempted. In plane *ABCD*, the optimal fruiting conditions of the San José Canner Tomato are shown as a function of night temperature (*A-B* axis) and day temperature (*B-C*

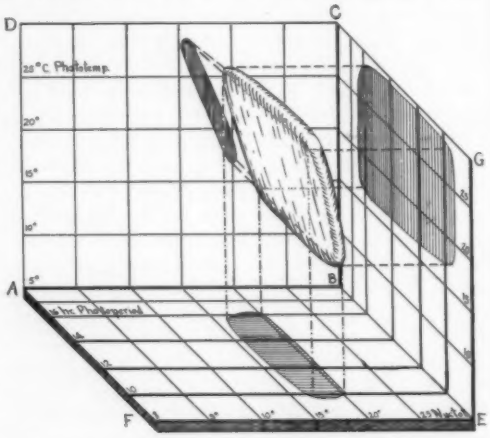

FIG. 4. Three-dimensional diagram showing optimal fruit-setting conditions of San José Canner Tomato plant, in terms of interactions of day temperature, photoperiod, and night temperature. Shaded areas on planes represent favorable combinations of any two of these factors. By projecting lines from these areas, three-dimensional figure in center is obtained, which represents favorable combinations of all three factors.

axis). This shows a narrow range of night temperatures, slightly modified by the much larger range of day temperatures, within which most fruit is set. In plane *ABEF* the photoperiod (*B-E* axis) is considered in relation to night temperature, and it appears that fruit set is good over a wide range of photoperiods but, again, is restricted by night temperature. Similarly, in plane *BCGE* the interrelationship of day temperature and photoperiod is shown, which is not critical at all. The optimal fruit setting conditions can now be presented in a three-dimensional grid *ABCDEFG*. The solid figure thus produced has been projected on planes *ABCD*, *ABEF*, and *BCGE*.

Within the same grid the climate of any particular region can be plotted by connecting the monthly averages, giving an oval-shaped figure. When a sufficiently long part of the climatic oval falls within the solid representing optimal fruit-setting conditions for

the San José Canner Tomato, it means that during those months it can be grown successfully in that particular climate. We can now fit any tomato variety to the climates that follow most closely its optimal growth requirements, or we can take a given climate and see which tomato varieties are most nearly optimal in it.

This shows that the effect of temperature is rather complex and cannot be expressed simply as a heat-sum. The heat-sum concept was introduced about 200 years ago and was worked out in some detail 100 years ago by Boussingault and DeCandolle. It holds that the development of a plant is dependent upon the total amount of heat to which it was subjected during its lifetime, expressed as degree-days. For wheat it was calculated that it ripened after having been exposed to 2,200 degree-days. This accounted for the fact that in colder climates it took wheat longer to mature than in warmer climates. A refinement of this method was introduced by Nuttonson, who incorporated the effect of day length in the heat-sum to account for the behavior of garden peas. Yet all heat-sum calculations are based on the false assumption that there is a direct proportionality between growth and temperature. Actually, above a certain optimal temperature the rate of development decreases with rising temperatures. Besides, it does not take into account that mainly night (or day) temperature controls development in certain plants. No heat-sum can account for the date of first ripening of tomato fruits, but forty days after flowering plants have been exposed for the first time to a series of five or more successive nights when the temperature did not drop below 15° C, the first ripe fruit will be harvested.

Other experiments lead to the same conclusion, that the development of a tomato plant does not depend on the total amount of heat to which it is subjected but on the proper diurnal distribution of heat. A set of tomato plants was subjected to eighteen different temperature treatments. All of them received exactly the same amount of artificial light. When the growth rates or the final weights of these plants were plotted as a function of either day or night temperatures, combining only the plants which received equal heat-sums (e.g., eight hours at 30° in light and sixteen hours at 4° in dark, or eight hours at 4° in light and sixteen hours of darkness at 17°, or eight hours at 17° in light and sixteen hours at 10° in darkness), a very pronounced optimum was found at 17° in light and 10° in darkness (and 20° in light and 17° in darkness), with growth dropping to one-third or less at the extreme lows in day or night temperatures. Therefore, not a heat-sum, but a proper day-night temperature balance determines their growth.

Instead of adding other details about the climatic response of the tomato plant, a few details about other plants will be given. Whereas the tomato needs a fairly warm night (15°–18° C) for reproduction through fruit set, other plants require much lower temperatures. The English daisy, for instance, only grows and flowers when the days are cool and the nights are 8°–13° C, with much the best flowering at the lower night temperature. The Iceland poppy has similar temperature requirements but, in addition, it needs long light treatments for flowering. At the other extreme we find the African violet, which flowers and grows best at temperatures higher than tomatoes. Under the conditions ideal for the African violet, the English daisy dies, and the tomato does not set fruit. On the other hand, the African violet dies when brought under the optimal conditions for the English daisy, which are also too cool for fruit set in the tomato.

Therefore, when the climatic responses of a number of plants are worked out in detail, we find marked differences that have a significant bearing on the distribution of these plants over the earth. It is necessary to revise our ideas about the temperature limits within which a plant can exist. It has been thought that freezing is the lower limit that most plants could stand, and this could be explained rather simply by the damage done inside the tissues by the formation of ice crystals. But an African violet dies if it is subjected for long periods to night temperatures of 10° C, far above any possible frost injury. Similarly, the English daisy dies when it is kept for a long enough period at temperatures of 20° or over. Such relatively low temperatures are far removed from any where actual heat damage to protoplasm can occur.

It must be concluded that the distribution of plants is not just a question of frost damage or heat coagulation, but is correlated with very specific temperature requirements, which are met only in certain climates. Whereas it was formerly supposed that plants from temperate climates could grow in the tropics but were crowded out by tropical plants better adapted to the climate, we now can say that many such cool-weather plants would die within a relatively short time in the tropics even without competition. Part of the reason for these misconceptions concerning temperature requirements of plants was the limitations of experimental facilities, which allowed only study of the seedling stages. Germination and seedling growth are usually best at temperatures substantially higher than optimal for later growth. Since we had exact information only about these early stages of plant development, we were misguided by extrapolation.

The adaptation of the plant to its physical environment goes much farther than merely a general relationship between type of climate and optimal growing

conditions. In nature we almost invariably find a higher temperature during the day than at night, a fact that is understandable on the basis of heat radiation from the sun during the day and radiation toward space at night. The range between day and night temperatures is greater as the climate is drier. Plants follow the daily shift in temperature with a similar shift in optimal growing temperatures. This can most easily be demonstrated in tropical plants where, throughout the year, day and night temperatures fluctuate over the same range. The orchid *Phalaenopsis amabilis* has an optimal night temperature of 21° C and an optimal day temperature in full sunlight of about 28° C. In its native habitat in the lowland Malaysian jungles, the mean night temperature is 20°–22° C, and the day temperature rises to as high as 30° in the full sun, but on the average is 27°–28°. Similarly close correlations between existing and required temperature ranges may be identified in other plants, but most of these still need much experimental work before they are well established.

Since plants in their natural surroundings are so closely adapted in temperature response to the existing temperatures, it follows that, once the temperature requirements of a particular plant are known, it is possible to find the best climate for this plant. But something else can be attempted. By a breeding program a recombination of characters of a given plant species can be accomplished. Once we know on which individual genetic units the climatic response to day temperature, night temperature, and photoperiod depends, we can create the plant variety that most closely harmonizes with the climate in which we want to grow that plant. Such a deliberate synthesis would then replace the standard method of selection for yield or general performance. The latter values depend on a large number of individual physiological processes, among which the responses to temperature and photoperiod are among the most important for the performance of the plant in the field.

An analysis of the genetical basis of climatic response may provide some interesting insight into the problem of evolution and migration of species, because it will indicate how many genes have to participate to allow invasion into new climatic territory, and it will show the limits of migration on the basis of available genetic material in the species. For there is no doubt that the genes controlling climatic response are most important in the survival of a species.

There are many other climatic factors that can be studied in the Earhart Plant Research Laboratory, which has one room equipped to maintain very low humidities (down to 10 per cent relative humidity), and another containing a wind tunnel, in which plants can be subjected to strong, even winds at constant temperature, humidity, and light. Another room has equipment to produce fog or rain at constant temperature and light. Two airtight rooms can be used for the study of effects of gases on plants and are now in use to establish which of the air contaminants cause such typical damage symptoms on plant leaves as are found in many large cities and were recently headlined for the Los Angeles area and connected there with smog.

One of the unique features of the laboratory is that a state of relative sterility is maintained. There have been no insects in the building, with the exception of a small outbreak of aphids, which had its source in some insufficiently fumigated plant material. Within half an hour of their discovery, the few aphid colonies were completely eradicated. Neither are there any virus or soil-borne diseases. Thus reactions to climatic conditions are not obscured by various degrees of insect infestation or spray damage. This relative sterility is maintained by strict adherence to quarantine measures. All materials entering the building are either sterilized with steam, fumigated with methylbromide, or sprayed with DDT. All persons entering change into special laboratory clothing and wash their hands so that they do not carry insects or virus into the building. The very large volume of air entering the building through the air-conditioning system is filtered, mechanically and electrically, to remove all solid particles, such as insects. The building is insectproof and is kept continuously under positive pressure, preventing the passive sucking in of contaminants. Visitors are restricted to professional biologists. Such restrictions are essential and have thus far proved completely successful. As a result, thousands of plants are growing without diseases or pests, with almost complete uniformity, provided they are subjected to the same environmental conditions. The number of fungus spores and bacteria carried by the air into the greenhouses is surprisingly low.

Now that the Earhart Plant Research Laboratory has passed the rigorous tests of actual operation, the greatest problem has become how to make it as effective as possible in furthering our knowledge of plants and plant behavior. At present the solution of this problem is sought along three lines: first, by appointing research workers and graduate students to study specific problems for which the laboratory offers special facilities; second, by making the facilities available to research workers from other institutions, who contribute to its maintenance cost; and, third, by attracting volunteer workers.

Technical Papers

Identification of Another Epidemic Respiratory Disease[1]

Thomas Francis, Jr., J. J. Quilligan, Jr., and Elva Minuse

Department of Epidemiology and Virus Laboratory, School of Public Health, University of Michigan, Ann Arbor

A mild outbreak of influenza associated with A-prime strains of virus occurred in Ann Arbor, Michigan, in the spring of 1950, and several characteristic strains were isolated. On March 20, a virus unrelated to known strains of the influenza group was isolated by amniotic inoculation of chick embryos from fresh throat garglings of a person ill on March 16. The illness experienced was similar clinically to a mild form of the influenza prevalent at the time and consisted of one day of headache and malaise, with short intervals of myalgia, but no fever was noted. Acute and convalescent blood specimens were obtained from the patient and showed rises in hemagglutination-inhibiting (HI) titer from 64 to 2,048, in complement-fixing titer from 0 to 64, and in neutralizing titer in eggs from 128 to 650. Similar tests against A, A-prime, and B strains of influenza virus showed no rises. This information clearly indicated the specificity of the virus (JJ) in relation to the illness.

In an effort to determine the relationship of this virus to the A-prime epidemic, tests were made with 52 pairs of sera that had been obtained in the acute and convalescent stages from patients among the students at the University of Michigan, ill with influenza during the epidemic phases of 1947 and 1950. None of them showed rises in titer to the JJ virus, although a majority did show typical rises in titer to strains of virus of the A-A-prime influenza group. However, it was noted that most of them did show moderately high HI titers to the JJ virus, suggesting that they had previously had experience with a virus of this type; a few of them had sufficiently high titers to suggest that their experience had been recent.

The possibility existed that the adults, because of the high titers, might not show a measurable response to infection with this virus. Attention was then directed to young children who would have less experience, and whose antibody responses would be more likely to reflect the occurrence of infection. Sera obtained from a group of children, aged 1–5½ years, who had been studied from August, 1946, to May, 1947, were available. They had been vaccinated with the PR8 strain of Type A influenza in the fall of 1946, and blood samples were obtained at intervals from August to November, 1946, and again in the latter part of April and early May, 1947 (*1*). During March and April, 1947, a sharp outbreak of A-prime influenza occurred. The serum samples from August through November could be compared with those obtained in May, 1947, for antibody rises against strains of influenza virus isolated from the epidemic. This was done and showed clear evidence of the prevalence of A-prime influenza in the Children's Home. The same sera were tested for HI antibodies against the JJ virus and, surprisingly, a large number of them showed a pronounced rise in antibodies in the sera taken in April and May, indicating that there had been a wide exposure to this virus in the interval between November and May.

Fortunately, acute and convalescent sera were also available from 11 of these children at the time of a respiratory illness in January and February, 1947. None of them presented a rise in antibodies to members of the influenza virus group or to JJ virus (Table 1). In fact, their sera were essentially devoid of antibody to the latter.

TABLE 1

TIME OF OCCURRENCE OF INFLUENZA A AND JJ VIRUS INFECTION ACCORDING TO HI TESTS

Illness	Total No.	+ A–A′	+ JJ	+ Both
Jan.–Feb., 1947	11	0	0	0
Mar.–Apr., 1947				
Adults	15	0	4	0
Children	18	11	2	2
Aug. 1946–May, 1947				
Children	68	16*	20†	32

* 13 of 16 had high antibody titers to JJ virus throughout the period of observation.

† 6 of 20 had high antibody titers to A′ throughout the period of observation.

During the influenza outbreak in March and April, pairs of sera were obtained from 33 patients, including 15 adults. Of the latter, 4 showed a rise in antibody to JJ, but none rose to influenza virus, although a majority did show high titers in the acute specimens. Of the 18 children, 11 showed sharp rises only to A-prime influenza, 2 to JJ only, and 2 to both—in contrast to the observations of January and February (Table 1). Seven other children had high titers to JJ in both the acute and convalescent sera, suggesting that they had been infected earlier with this virus.

The sera that had been obtained from 68 of the children at the end of April or early May, 1947, were then examined by HI tests in comparison with specimens from the autumn of 1946. It is seen in the last line of Table 1 that in 16 instances there were rises in titer to the A–A-prime type alone; in 20, to JJ alone; and in 32 to

[1] This investigation was conducted under the auspices of the Commission on Influenza, Armed Forces Epidemiological Board, Office of the Surgeon General, U. S. Army, Washington, D. C.

TABLE 2

SPECIFICITY OF HI TESTS WITH SERIAL SERUM SPECIMENS FROM INDIVIDUALS AND INFLUENZA A′ AND JJ VIRUSES

Case No.	Age	Virus	1946 Vaccination period		1947 Illness period				
							A′ epidemic		
			Aug.	Nov.	Jan.	Feb.	Mar.	Apr.	May
2	1 yr	A′	< 32	< 32	< 32	< 32			< 32
		JJ	32	32	< 32	< 32			512
5	1½	A′	32	1,024					512
		JJ	32	< 32		< 32			1,024
14	2	A′	< 32						1,024
		JJ	< 32						< 32
39	3½	A′	< 32	32					1,024
		JJ	< 32	< 32	< 32	< 32			< 32
17	2½	A′	< 32	< 32			< 32	512	512
		JJ	128	128			128	128	128
28	3	A′	< 32						512
		JJ	1,024						256
15	2	A′	< 32						512
		JJ	< 32						512
20	2½	A′	< 32						512
		JJ		128					4,096
P.M.	20+	A′					< 32	< 32	
		JJ					32	4,096	

both. These data add to the evidence that the two diseases were concurrent in the population and of about the same incidence during the spring of 1947, and that they are immunologically independent.

The mean HI pre- and postepidemic titers to JJ virus in the above group were 32 and 400, respectively. Study of 30 acute and convalescent sera from patients 8–18 years of age in another institution yielded titers of 128 and 117, respectively, and, among the adult patients of 1947 and 1950, titers of 143 and 151, respectively, were found. Again the trend toward greater ease of identification of this infection in young children is illustrated.

The HI reactions obtained with the different specimens of sera of individual subjects to A-prime strains of influenza virus and to the JJ virus are listed in Table 2. They exemplify instances in which, according to HI tests, there were antibody rises to JJ alone, to both A–A-prime and JJ, or to A-prime alone, and clearly demonstrate the fact that the rises in antibody against both types of viruses occurred in the interval when influenza was epidemic. Two children with consistently high titers to JJ are included, as well as 1 adult who showed rises to JJ alone and was ill with symptoms of acute respiratory disease during the epidemic period. These results indicate the independent manner in which antibodies to the two viruses behave.

Identification and immunological relations of virus. Observation of the pecularities of the hemagglutinating property and growth characteristics of the JJ virus suggested its similarity to the strain of virus called 1233, which was isolated by Taylor (*8*) in 1947, also during an epidemic of influenza A-prime. Cross reactions with that virus and with serum obtained from Taylor demonstrated that the JJ and the 1233 strains are essentially identical. Moreover, serological tests with human sera gave closely parallel results. The 1233 strain was not being used in this laboratory during the period in which the JJ strain was isolated. The fact that both strains were isolated during epidemics of A-prime influenza suggested promptly that the new virus was related to that group of influenza viruses. The clinical histories and examinations of patients showing one or the other illness gave no clearly discriminating differences, nor was there evidence of a prevalence of any other well-recognized disease in the Children's Home at the time of the study. However, Taylor's studies with animal sera failed to show a relation to known influenza virus, to Newcastle disease virus, or to mumps virus; and his results are fully confirmed by investigations in this laboratory. Sera from mice vaccinated with the PR8 A, the FM1, or Rhodes A-prime strains had no antibodies to the JJ virus, and vice versa. Mice vaccinated with the JJ virus were not immune to the PR8, FM1, or Lee, Type B, strains. Ferrets inoculated with JJ virus had mild fever but little clinical evidence of infection. Their late sera, however, reacted equally with the JJ and 1233 strains, but not to A, A-prime, and B strains.

Because of their broader range of reaction, the extensive tests made in the present study with human sera are of still greater significance. Although 32 of the children from 1947 developed antibodies to both A-prime and JJ viruses, the remaining 36 showed specific reactions in which no cross relation between Types A, A-prime, or B influenza virus and JJ virus was detectable by HI, complement-fixation, or neutralization tests in eggs. Patients from the influenza B epidemic of 1945 (*3*) revealed no rise in antibody to the JJ virus. Moreover, subjects vaccinated against PR8, FM1, or Lee strains exhibit no rise in antibodies to the JJ virus. The virus under consideration thus seems to be serologically and immunologically distinct from previously identified strains of influenza virus.

The possibility remained, however, that it might be related to some other well-established clinical disease. Pairs of acute and convalescent sera were examined from cases of rubeola, rubella, infectious mononucleosis,[2] atypical pneumonia,[3] and the common cold,[3] with negative results. A group of sera from adults with unidentified respiratory disease, furnished by J. E. Salk, of the University of Pittsburgh, gave no positive results. Sera positive to JJ virus were negative to Newcastle disease virus. Rabbit antimumps serum, mouse sera against Melnick's Texas, Ohio, and Connecticut strains of Coxsackie virus, and mouse anti-PVM serum were all negative to the JJ virus. The egg membranes or embryos exhibit no lesions representative of the pox groups of virus. LCL bodies have not been seen, but electron microscopy of amniotic fluid has disclosed numerous filaments. There is, therefore, in these results no evidence that this virus is related to the common infectious diseases mentioned above. Hirst suggests on the basis of

[2] Sera obtained from C. J. D. Zarafonetis, of the University of Michigan.

[3] Sera obtained from A. E. Feller, of Western Reserve University.

the action of this virus upon cell receptors and egg-white inhibitor that it may be unrelated to known members of the group of hemagglutinating respiratory viruses (*4*).

Although Taylor concluded that the virus "may prove of little public health import," and Hirst noted no significant rises of antibody to it, the present data indicate that it is causally related to a widespread respiratory disease that occurs in epidemic form. Neither Taylor nor Hirst refers to the high incidence of antibodies in the adult population, which to our minds strongly indicates that the population has been thoroughly seeded. On the other hand, in young children titers are generally extremely low and, when present, tend to be quite high, suggesting recent infection. Moreover, tests with sera from as far back as 1936 indicate that the virus has been circulating since that time at least. At present, the frequency with which this virus causes clinical disease is difficult to estimate, but the epidemic herein described not only involved children but also a significant number of adults among the limited number in the institution. The clinical features in adults are not yet well outlined, but fever, cough, and coryza in the children were the common signs. The study emphasizes a frequently neglected opportunity to clarify epidemiological problems by the study of young children.

The association of the epidemic disease with influenza, the basic clinical picture, and the wide distribution of antibodies in the human population, as well as the serological and immunological characteristics of the virus, readily invite consideration of the name "Influenza C." Further studies, a number of which are under way, will determine the appropriateness of this suggestion.

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Kinetic Mechanisms and Hydrocarbon Flame Spectra

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It is now known (*2, 3, 6, 7, 15*) that when hydrocarbons such as C_2H_2, C_2H_4, and CH_4 burn in oxygen or air under various conditions of fuel-oxygen ratio, the flame spectrum exhibits the electronic band systems of O_2, OH, CH, C_2, as well as the hydrocarbon flame bands (2,500–4,100 A) originally obtained by Vaidya and attributed to the HCO radical.[2] The question of the manner of formation of the excited molecules and radicals in hydrocarbon flames has been a matter of considerable discussion (*2, 3*), but it has by no means been settled. The object of the present note is to report some new spectroscopic findings and to suggest kinetic mechanisms that might account for the main types of reactions that occur. The discussion is chiefly confined to the burning of acetylene in oxygen, but will be extended to other hydrocarbons in later papers.

If one designates the oxygen-fuel ratio by ρ, with $\rho = \rho_s$ for stoichiometric proportions, the results of the spectroscopic studies for the acetylene-oxygen flame may be summarized as follows (*2, 3, 6, 7*): When $\rho = \rho_s$, one finds from the inner cone the band systems of OH, CH; the Mulliken, Deslandres-D'Azambuja, Phillips, and Swan systems of C_2; the CO Fourth Positive bands; the carbon line at 2,479 A and the hydrocarbon flame bands weakly. When $\rho < \rho_s$, the Fox-Herzberg bands of C_2 also become prominent, but the hydrocarbon flame bands are very weak, if present at all. When $\rho > \rho_s$, the OH and CH bands remain strong, the bands of C_2 become very weak, the Schumann-Runge bands of O_2 increase in intensity as the oxygen concentration rises, and the hydrocarbon flame bands are enhanced.

Noting that the hydrocarbon flame bands are strongest when burning with air, with excess oxygen, or as a cool flame (*2, 3*), we have used both argon and CO_2 as diluents. The introduction of argon into the acetylene-oxygen mixture enhances the hydrocarbon flame bands somewhat, but the effect of CO_2 is particularly striking. Burning $C_2H_2 + O_2 + CO_2$ in volume proportions of about 1 : 10 : 10, and with high mass flow from a multiple-jet burner operating in air, one finds the hydrocarbon flame bands to be the most prominent feature of the spectrum (extending from ~ 2,350–~ 4,100 A), the OH and CH bands to be quite weak, the C_2 bands very weak, and on the long wavelength side of the hydrocarbon flame bands, one finds weak CO flame bands. With a Bausch & Lomb medium quartz spectrograph using a 30 μ slit and type II-O Eastman plates, we have obtained well-exposed spectrograms of the hydrocarbon flame bands in the region 3,000–4,000 A in as short a time as about 30 sec. It is also interesting to note that the CO flame bands are very well developed in the oxyhydrogen flame to which is added CO_2 in rather high concentration.

It would appear that these facts may be explained qualitatively along the following lines. Oxygen is known to interact with unsaturated hydrocarbons by two distinct mechanisms (see, for example, ref. [*1*]), which may be referred to as the addition and peroxide mechanisms. In the case of acetylene the addition mechanism involves such steps as the following:

$$(1)\quad O_2 + C_2H_2 \rightarrow H{-}C(=O){-}O{-}C{=}O{-}H \rightarrow 2CHO + \sim 55 \text{ kcal}$$
$$(2)\quad HCO \rightarrow H + CO - \sim 20 \text{ kcal}$$
$$(3)\quad O_2 + HCO \rightarrow HO_2 + CO + \sim 40 \text{ kcal}$$
$$(4)\quad CO + \tfrac{1}{2}O_2 \rightarrow CO_2 \text{ (via chain mechanism)}$$

Since reaction (1) evolves about 55 kcal of energy, it is clear that, with the aid of thermal energy, it is possible for HCO to be formed occasionally in an electronically

[1] A portion of this work was supported by the U. S. Navy Bureau of Ordnance, Contract NOrd-7386.

[2] In our opinion there is as yet no unequivocal spectroscopic evidence that the emitter is HCO; however, we tend to favor this identification, as our kinetic mechanism makes it seem likely that HCO is produced exothermically.

excited state. Similarly, reaction (4), proceeding by a chain mechanism involving oxygen atoms, is known to give rise to excited CO_2 (*4, 10, 11, 12, 13*). The addition mechanism is therefore consistent with the formation of HCO and CO_2 in electronically excited states.

In the peroxide mechanism the following steps are among those that may be expected to occur:

$$
\begin{array}{ll}
(1) & C_2H_2 + O_2 \rightarrow \\
(2) & H{-}C{\equiv}C{-} + O_2 \rightarrow \\
(3) & H{-}C{\equiv}C{-}O{-}O{-} + C_2H_2 \rightarrow \\
(4) & H{-}C{\equiv}C{-}O{-}O{-}H \rightarrow \\
(5) & H{-}C{=}C{=}O \rightarrow \\
(6) & H{-}C{\equiv}C{-} + O_2 \rightarrow \\
(7) & 2CH \rightarrow
\end{array}
$$

Reactions (4), (5), (6), and (7) would seem to be the most likely reactions producing OH, CH, and C_2, and reaction (7), being a radical-radical reaction, is probably very unimportant. Reactions (4), (5), and (6) are all endothermic; they are therefore slow, and there is a negligible possibility that they will produce OH, CH, and C_2 in electronically excited states.

In order to account for the spectroscopic result that OH, CH, and C_2 are electronically excited in the flame, it therefore seems necessary to assume, as was done in the case of the carbon-monoxide oxidation (*14*), that transfers of electronic energy occur:

$$
\left\{\begin{matrix} CO_2^* \\ HCO^* \end{matrix}\right\} + \left\{\begin{matrix} C_2 \\ OH \\ CH \end{matrix}\right\} \rightarrow \left\{\begin{matrix} CO_2 \\ HCO \end{matrix}\right\} + \left\{\begin{matrix} C_2^* \\ OH^* \\ CH^* \end{matrix}\right\}
$$

Our interpretation of the spectroscopic results, in terms of the kinetic mechanisms, may be summarized as follows: Reaction proceeds mainly by the exothermic addition mechanism and, of the HCO radicals and CO_2 molecules produced, very small fractions are electronically excited. At the same time very small amounts of C_2, CH, and OH are produced by the peroxide mechanism. In order to explain the fact that in hot flames there is more radiation from C_2, CH, and OH than from HCO, we suppose that HCO^* and CO_2^* have long radiative lives and may transfer energy to C_2, CH, and OH on collision. This situation is similar to that in the carbon-monoxide flame, in which much of the radiation is due to O_2 (Schumann-Runge bands) (*5, 8, 9*) in spite of the fact that it is the CO_2^* molecule that is formed directly.

It is clear that most of the HCO^* and CO_2^* will only transfer energy to C_2, CH, and OH provided the latter are present at sufficiently high concentrations, i.e., provided the flame is hot. If the flame is cooled, by the addition of CO_2 or by other means, the concentrations of the endothermically produced C_2, CH, and OH will be reduced markedly, and there will be much less energy transfer from HCO^* and CO_2^*. The enhancement of the hydrocarbon flame bands under these conditions is thus readily explained. The fact that the C_2 bands are most sharply affected by change in temperature finds a ready explanation in terms of our mechanism, for C_2 is produced by the most endothermic reaction, which is therefore to be expected to have the highest temperature coefficient.

We are continuing a variety of experimental and theoretical studies in the hope that more definite evidence may be found concerning the identification of the emitter of the hydrocarbon flame bands and the details of the kinetic mechanisms involved in hydrocarbon combustion. We also hope to publish in the near future a more detailed discussion of the results reported here.

$H{-}C{\equiv}C{-} + HO_2 - \sim 60$ kcal
$H{-}C{\equiv}C{-}O{-}O{-} + \sim 50$ kcal
$H{-}C{\equiv}C{-}O{-}O{-}H + C_2H - \sim 10$ kcal
$H{-}C{\equiv}C{=}O + OH - \sim 30$ kcal
$CH + CO - \sim 75$ kcal
$HO_2 + C_2 - \sim 120$ kcal
$C_2 + H_2 + \sim 30$ kcal

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The Function of the Symbiotic Yeasts of Two Insect Species, *Lasioderma serricorne* F. and *Stegobium* (*Sitodrepa*) *paniceum* L.

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It was shown by Fraenkel and Blewett (*3*), and Blewett and Fraenkel (*1*), that the symbiotic yeasts, which occur intracellularly in mycetomes situated at the junction of the fore- and mid-gut of two species of anobiid beetles, *Lasioderma serricorne* and *Stegobium paniceum*, supply vitamins of the B group in significant amounts and make it possible for their hosts to subsist on foods very low in vitamins of that group. Indeed, the larvae grew normally, or almost so, on synthetic diets which were entirely lacking in such important factors as thiamin, riboflavin, nicotinic acid, pyridoxin, or pantothenic acid. When these yeasts were eliminated from the hosts

TABLE 1

GROWTH OF LARVAE OF *Lasioderma* AND *Stegobium* IN THE PRESENCE AND ABSENCE OF THEIR OWN SYMBIONTS, IN THE PRESENCE OF SYMBIONTS FROM THE OTHER HOST, AND IN THE PRESENCE OR ABSENCE OF VITAMINS OF THE B COMPLEX*

	Lasioderma serricorne						*Stegobium paniceum*					
	Normal		Without symbionts		Sterilized, reinfested with *Stegobium* yeasts		Normal		Without symbionts		Sterilized, reinfested with *Lasioderma* yeasts	
	No.	Period, days	No.	Period, days	No.	Period, days	No.	Period, days	No.	Period, days	No.	Period, days
Basic diet	18	26–35	16	29–39	14	27–40	16	42–55	13	46–57	11	45–60
No thiamin	8	36–43	7	35–47	2	40–43	0	.....	0	.....	7	49–85
No riboflavin	16	26–38	0	.....	6	33–41	13	43–63	0	.....	7	42–62
No nicotinic acid	13	30–36	0	.....	10	34–47	14	44–59	0	.....	8	47–68
No pyridoxin	13	33–42	0	.....	0	.....	12	45–62	0	.....	11	49–68
No pantothenic acid	15	28–37	0	.....	8	33–41	9	44–62	0	.....	7	47–82
No choline	10	29–43	0	.....	9	34–45	13	43–60	9	44–66	7	46–62
No inositol	15	30–33	15	27–42	9	27–47	14	42–57	13	46–62	11	42–69
No biotin	10	42–52	8	46–55	3	42–46	6	57–105	0	.....	6	60–83
No pteroylglutamic acid	15	29–38	5	39–48	8	34–44	9	46–60	0	.....	9	46–79
Wheat bran + 5% yeast	20	24–28	17	27–30	14	25–27	19	30–32	..	.....	..	.....

* Basic diet consisted of casein 20, glucose 80, cholesterol 1, and McCollum's salt mixture 2, with addition of the following B-complex vitamins (expressed in μg/g of diet): thiamin 25, riboflavin 12.5, nicotinic acid 25, pyridoxin 12.5, pantothenic acid 25, choline 500, inositol 250, pteroylglutamic acid 2.5, and biotin 0.1. Total number of adults, out of 20, and duration of larval and pupal periods are given. Tests run at 27° C and 70% relative humidity.

by a simple surface sterilization of the eggs, growth in the resulting larvae ceased entirely in the absence of any of these vitamins. These experiments have now been repeated with similar results and extended to diets which were lacking also in either biotin or pteroylglutamic acid (Table 1). There can be no doubt that biotin and pteroylglutamic acid are also supplied by the yeasts in significant amounts.

It has proved possible to cultivate these symbiotic yeasts outside the bodies in Hansen's solution, those from *Lasioderma* responding more favorably to cultivation than those from *Stegobium*. The yeasts from the two species are strikingly different in shape, appearance, and mode of budding, both *in situ* and in culture (Figs. 1, 2). They have so far been classified only very imperfectly as belonging to the genus *Saccharomyces*. Buchner (*2*) named the symbionts of *Stegobium* as *Saccharomyces anobii*. Sporulation has never been observed, but budding frequently occurs in larvae and pupae, though rarely in adults. It was noted that in the pupa of *Lasioderma*, in contrast with the larval and adult stages, yeast cells

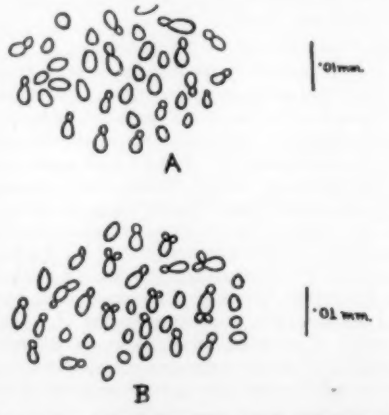

FIG. 1. Yeastlike symbionts of *Lasioderma serricorne*: *A*, mycetomic yeast of the larvae; *B*, mycetomic yeast of the pupa.

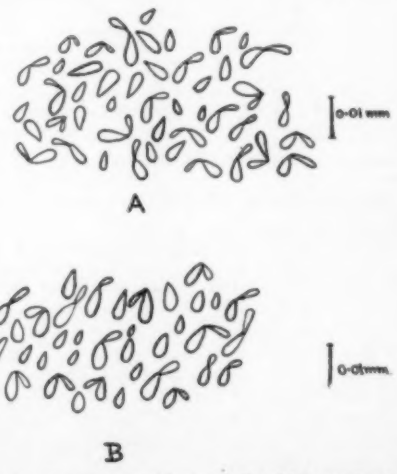

FIG. 2. Yeastlike symbionts of *Stegobium paniceum*: *A*, mycetomic yeast of the larva; *B*, yeast cultivated in Hansen's solution.

frequently show two buds (*B*, Fig. 1). The yeasts do not seem to ferment glucose with development of carbon dioxide.

Reimplanted into "sterilized" insects from culture, the yeast cells reestablished themselves normally in the mycetomes. This reinhabitation was achieved by various methods, of which smearing the surface of eggs or feeding sterilized insects with yeast culture proved the most successful. Indeed, yeast from *Lasioderma* settled apparently normally in *Stegobium*, and from *Stegobium* in *Lasioderma*, without altering their characteristic appearance and physiological function. It is evident, from a comparison of the results in Table 1, that with *Lasioderma* the effect of yeast from *Lasioderma* is, in most cases of individual vitamin deficiencies, superior to that of yeasts from *Stegobium*, and the same holds, though to a lesser degree, for yeasts from *Stegobium*, *mutatis mutandis*. Altogether, it seems that yeasts from *Lasioderma* may contain larger amounts of certain factors, especially thiaman, pyridoxin, pantothenic acid, biotin, and pteroylglutamic acid, than those from *Stegobium*. Inositol is not required by either species, and *Stegobium* is little affected by a deficiency in choline.

It is shown in Table 1 that "sterilized" insects, in the presence of all 9 vitamins, grow about as well as normal insects. In the absence of the pure vitamins, normal growth ensues with the addition of either 2.5% dried brewers' yeast, or 2.5% dried *Lasioderma* yeast from pure culture. This again clearly shows *Lasioderma* yeast to be a good source of all the known vitamins of the B complex.

TABLE 2

GROWTH OF LARVAE OF *Lasioderma* AND *Stegobium* ON THE BASIC DIET (Table 1) IN THE PRESENCE AND ABSENCE OF SYMBIONTS AND WITH AND WITHOUT THE ADDITION OF CHOLESTEROL

	Lasioderma				*Stegobium*			
	With symbionts		Without symbionts		With symbionts		Without symbionts	
	No.	Period, days	No.	Period, days	No.	Period, days	No.	Period, days
With cholesterol	15	30–46	15	30–36	13	38–57	14	41–62
Without cholesterol	14	33–43	7	33–41	7	35–47	2	50–62
Wheat bran + 5% yeast	19	25–29	17	25–34	..	.....	..	.....

The yeasts in our two species also serve for their hosts as sources of sterols. It has been shown for many insects, including *Lasioderma* and *Stegobium* (*4*), that a sterol is a necessary constituent of the diet. Omission of cholesterol from the synthetic diet has little effect on the normal larva of *Lasioderma* and some effect on the normal larva of *Stegobium*. In the "sterilized" larvae, however, the sterol-free diet becomes relatively more inferior (Table 2).

A full report of these observations will appear elsewhere.

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Some New Plant-Growth Inhibitors[1]

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It is intended in this report to describe briefly the inhibitory action on the growth of healthy and tumor tissue of higher plants of certain compounds that have shown promise as chemotherapeutic agents in the treatment of cancer (*2–5*). The growth-inhibiting action of 57 different compounds has been assessed in this laboratory. As test object in the preliminary survey, small (5-mm) fragments of stem tissue of the garden chrysanthemum var. Golden Treasure were employed. These were more uniform in their response than were the carrot fragments used in an earlier study (*1*). The fragments were inoculated with crown-gall bacteria (strain B.P.) and cultured for 3 days *in vitro* in small tubes containing 3 ml sucrose-mineral agar. An aqueous solution of the substance to be tested (conc, 1 mg/ml) was then applied to the surface of the developing tumor. Inhibition of tumor growth generally became evident 3 days later. Seven sulfonamides, 6 antibiotic substances, 9 plant-growth hormones, and 4 purine and pyrimidine derivatives proved inactive. The most active growth inhibitors belonged to the group of analogues of pteroylglutamic acid. Certain nitrogen mustards, 8-azaguanine (guanazolo), and cortisone also exerted an inhibitory action on the growth of the crown-gall tumors.

The action of these compounds on tumor and healthy plant tissue was compared in a series of *in vitro* tests. Various concentrations of the substances to be tested were added to suitable nutrient media in which fragments of bacteria-free crown-gall tumor tissue of sunflower, excised tomato roots, or excised sunflower embryos were cultured aseptically. The tissue fragments were weighed at the beginning and end of the 4-week culture period, and their percentage weight increases were calculated.

The most powerful growth-inhibiting action was possessed by 4-amino-N^{10}-methylpteroylglutamic acid, (A-methopterin), 4-amino-9-methyl P.G.A., (A-ninopterin), and 4-amino-9, N^{10}-dimethyl P.G.A., (A-denopterin). These compounds completely suppressed the growth of excised tomato roots in a concentration of 1 μg/litre. The growth of sunflower tumor tissue and embryos was only slightly inhibited at this low concentration but was almost completely inhibited by concentrations of 10–100

[1] This work was done in part under a grant-in-aid from the American Cancer Society upon recommendation of the Committee on Growth of the National Research Council.

FIG. 1. Sunflower plant on left was sprayed once with a solution of 0.1 mg/ml A-methopterin. It has not died, but its growth has been almost completely inhibited. Plant on right was sprayed with water only.

μg/litre of the active compounds. 4-Amino-P.G.A., (Aminopterin), 4-aminopteroylasparatic acid (Aminoanfol), and 4-amino-α-glutamyl-α-glutamyl glutamic acid (Amino-teropterin) exerted an inhibitory action about one-tenth as powerful as that of the first 3 compounds. No reversal of the inhibition could be obtained by the addition of pteroylglutamic acid to the medium containing A-methopterin. Pteroylglutamic acid itself inhibited the growth of these tissues at concentrations above 10 mg/litre.

A solution of A-methopterin (0.1 mg/ml) applied locally to young crown-gall tumors on sunflower plants completely inhibited growth of the tumors without damaging the plant, provided the tumors were located on mature tissue. Serious damage resulted when this substance was applied at this concentration to tumors on young, growing stems. Sunflower plants sprayed with this concentration of A-methopterin grew at a greatly diminished rate (Fig. 1) but did not die. Onion roots grown in 0.1 mg/litre A-methopterin were devoid of mitoses during the first 24 hr after exposure to this compound. After 48 hr mitoses were again observed. It seemed probable that these compounds acted by interfering with cell division.

The nitrogen mustard, bis-ß-chloroethylmethyl amine, totally inhibited the growth of excised tomato roots exposed for 1 hr to a concentration of 1 mg/litre. Tumor and embryo tissue of sunflower was less affected by this agent. The growth-inhibitory action of guanazolo was detectable at concentrations of 1 mg/litre in all 3 tissues. Cortisone strongly inhibited the growth of bacteria-free crown-gall tissue of sunflower at a concentration of 1 mg/ml. The tissue fragments recovered and grew at their normal rate as soon as the cortisone was removed.

None of the substances tested exerted a specific inhibitory effect on tumor as opposed to healthy tissue. Tissue of excised tomato roots proved more sensitive to the inhibitory action of these agents than did the other tissues tested. It would appear that all these materials, with the possible exception of cortisone, act by interfering with the process of cell division, but that they affect tumor and healthy cells equally.

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An Antigenically Distinct Subtype of Influenza Virus A Which is Virulent for Mice in Primary Passage of Allantoic Fluid[1]

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Influenza virus, when introduced nasally in mice, following primary growth in the chick embryo, usually produces no clinical disease or histological change. The virus has been shown to multiply in the lungs of these apparently normal mice (*2*, *6*). After several passages in mice, they are killed by lung suspensions containing virus in high dilution.

Kalter (*3*) recovered one strain of influenza virus in 1947 which was strikingly different from another influenza virus isolated at the same time, in that it was invariably fatal for white mice in 3–5 days. The lungs showed complete consolidation, typical of influenza virus infection. There was no explanation for this behavior, but Kalter stated that the possibility of a toxic substance had not been eliminated.

Payzin and Okkan (*5*) recovered 3 influenza virus strains directly from cases in mice which occurred during an epidemic in Ankara in 1949. The strains attained high mouse virulence after 5 serial passages in mice. The

[1] This study was supported in part by a grant from the Division of Research Grants and Fellowships, National Institutes of Health, U. S. Public Health Service.

TABLE 1

ANTIGENIC RELATIONSHIP BETWEEN THE 5 NEW STRAINS AND OTHER A OR A′ STRAINS AS DETERMINED BY SERUM-VIRUS NEUTRALIZATION TESTS IN MICE

	Influenza Viruses										
	Baltimore strains						Other A or A′ strains				
Sera	Thompson	Icenroad	Morton	Hume	Vincentes	Hyde	FM1	WS	15 Swine	Weiss	PR8
Thompson	625–3,125	3,125	625	625	3,125	3,125	< 5	< 5	< 5	25–125	< 5–25*
Icenroad	625	3,125	3,125	625	3,125	3,125	< 5	< 5	< 5	125	5–25*
Morton	625	3,125	625	625	3,125	3,125	< 5	< 5	< 5	25–625*	5–25*
Hume	625–3,125	3,125	625	625–3,125	3,125	3,125	< 5–5	< 5	< 5	125–625*	5–25*
Vincentes	3,125	3,125	3,125	3,125	3,125	3,125	< 5	< 5	< 5	125–625*	5–25*
Hyde	625	3,125	625	625	3,125	3,125	< 5	5	< 5	25–125*	25
FM1	< 5	< 5	< 5	< 5	< 5	< 5	125–625	< 5	< 5		< 5
WS	< 5		< 5	< 5		< 5	5–25*	3,125	< 5	3,125	3,125
15 Swine	< 5	< 5	< 5	< 5	< 5	< 5	< 25	< 5	3,125		25
Weiss	25	25	< 5	5	5–625*	5–625*	5–125*	25–625*	< 5	3,125	625
PR8	< 5	25	< 5	5	5–125	5–125	< 5	625	< 5	625	3,125

* The highest dilution of antigen used was 1 : 3,125. End points not clear-cut.

titers were not given, but a report from Dr. Andrewes in London is quoted to the effect that they differed serologically from all the "classical strains."

The present study indicates that there are influenza virus strains which behave as laboratory mouse-adapted strains on first passage from eggs to mice. Five strains from among 35 influenza virus strains routinely isolated in the Baltimore area during the years 1946, 1947, and 1948 differed from the currently prevalent A′ strains in that they were highly pneumotropic for mice. They constituted an antigenically distinct group and differed from other A and A′ strains, with the exception of one isolated in 1935.

Two of the 5 strains were isolated from the lungs of fatal cases of pneumonia in which pneumococci were also present (*4*). One case occurred in May, 1946, and the other in February, 1947. The remaining 3 strains were recovered in March, 1947, from throat washings of influenza patients. An influenza epidemic was occurring in Baltimore at this time, and the predominating strains recovered were A′.

The 35 influenza virus strains were isolated by amniotic inoculation of embryonated eggs. Subsequently, they were maintained in the laboratory by allantoic passage. Eleven-day-old embryonated eggs were inoculated into the allantoic sac with 0.1–0.2 ml of 10^{-5}–10^{-6} dilutions of infected allantoic fluid in broth. The eggs were incubated 48 hr, and the fluid was harvested in the usual way. The fluid from each egg was tested for hemagglutination, using equal vol of 3 serial tenfold virus dilutions and 0.25% washed chicken erythrocytes. Pools were made of fluids which showed partial or complete hemagglutination in the last and highest virus dilutions. The pooled virus was cultured on blood agar and a semisolid meat infusion medium to insure freedom from bacterial contamination.

The pooled bacteria-free allantoic fluid containing virus was used to infect and also to immunize mice. Mice were infected nasally with 0.05 ml of each of several dilutions of virus-infected allantoic fluid. After 3 days some of the living mice were sacrificed. The lungs were removed aseptically, weighed, ground with alundum, and diluted with *M*/10 phosphate buffer pH 7.0 to make a 10^{-1} dilution. Further tenfold dilutions were made in meat infusion broth of pH 7.4–7.6. Titrations were then carried out by inoculating groups of mice nasally with 0.05 ml of the different dilutions of mouse lung virus. These mice were observed for 10 days, and deaths were recorded.

One egg-adapted strain in allantoic fluid killed mice in a 10^{-4} dilution, 2 strains in a 10^{-5} dilution, and 1 in a 10^{-6} dilution, the highest dilution used. Titrations of the first and second mouse passage virus material killed mice in dilutions ranging from $10^{-4.75}$–$10^{-5.62}$. One strain, Icenroad, was not tested until it had been passed through several mice. This gave a titer of $10^{-5.62}$ when tested.

Mice were immunized intraperitoneally with graded doses of live virus, and neutralization tests with their sera were carried out according to a method previously described (*1*). The results are given in Table 1. The figures express the highest dilution of antigen which produced serum capable of neutralizing the virus in a final dilution of 1 : 4.

The 5 strains studied were similar and resembled the Hyde strain. This strain was isolated from nasal washings from a case of influenza in Alaska in 1935. Little or no immunological reactions were given with the FM1, 15 Swine, or WS strains, while varying cross-immunological reactions were found with the PR8 and Weiss strains when live antigens were used.

Lee influenza virus B did not cross immunologically with Thompson, Icenroad, Hume, or the Hyde strains by the methods employed.

Commercial influenza virus vaccines prepared by different methods and showing satisfactory potency with respect to the PR8 and Weiss or PR8 and FM1 strains afforded little or no protection against either the Hyde strain or the 5 new strains.

A more complete presentation of the data in this paper is in preparation. Further studies are necessary to determine the full meaning of the discovery of these antigenically different influenza virus strains at a time when the predominating influenza virus strains were A′.

The report is intended to emphasize the importance of

studying new influenza virus strains in mice, as well as in embryonated eggs. The observation that influenza virus strains may be pathogenic for mice without "blind" passage suggests that pathogenicity or lack of pathogenicity may be a characteristic of specific groups of influenza viruses with other biological properties in common.

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On the Validity of an Assumption of Resonance Theory[1]

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This discussion is concerned with an assumption of resonance theory which validates its application to the consideration of organic molecules. For the present purpose the resonance theory approach to organic molecules may be formulated as follows: There are some organic molecules whose properties cannot be satisfactorily described in terms of the structural formulas in current use. In such cases the properties of the molecules may be understood by considering the actual structure of the molecule to be derived in a dynamic manner from the several structures which may be represented in terms of the classical symbols. By the structural formulas in current use is meant the representation of carbon-to-carbon bonds as single, double, and triple bonds.

If this formulation of the resonance approach be accepted, then the following assumption is necessary for the application of resonance theory. Carbon-to-carbon bond distances not corresponding to the values represented conventionally by single, double, and triple bonds are distributed continuously throughout the remainder of the range of possible bond distances. The necessity of this assumption may be justified by the following argument. If the distribution of the bond distances is grouped rather than continuous in the intervening regions, then the resonance method must be considered to be logically unsatisfactory since (1) it then ignores an inherent order in the physical data it considered, and (2) it logically tends to the consideration of each particular molecule as a unique case.

The validity of the assumption as to the continuous distribution of bond distance values can be determined by an examination of existing data. Two questions must be considered:

1. Do the measured values of carbon-to-carbon bond distances appear to form a continuous or a grouped distribution?

2. If the distribution of these values appears to be grouped, do the members of each group bear a generic or analogous relation to each other with respect to other known properties?

Table 1 shows the frequency distribution of nominal carbon-to-carbon bond distances. The values were taken from the collection of Wheland (*2*). The areas corresponding to single, double, and triple bonds are quite well defined. In the region between the single and double bond there are apparently two additional groups of values which are designated along with the groups corresponding to the single, double, and triple bonds by Roman numerals. This readily apparent grouping provides the answer to the first question. Carbon-to-carbon bond distances in organic molecules are apparently not continuously distributed.

TABLE 1

Distribution of Carbon-to-Carbon Bond Distance

Distance in A	No. of cases	Bond type	Group
1.60	x		
.59	xx		
.58	xx		
.57	xx		
.56	x		
1.55	x		
.54	xxxxx xxxxx xxxxx xxx	Single	I
.53	xxxxx		
.52	xxxxx x		
.51	xx		
1.50	xxxx		
.49	xx		
.48	xxxx		
.47	xxxxx xxxx		II
.46	xxxx		
1.45	x		
.44	xxx		
.43			
.42	xxxxx xxxxx		
.41	xxxxx		
1.40	xxxxx		III
.39	xxxxx xxxxx xxxxx		
.38	x		
.37	x		
.36	x		
1.35	xxx		
.34	xxx	Double	IV
.33	xxx		
.32	x		
.31			
1.30			
.29	x		
.21	x		
1.20	xxx	Triple	V
.19	xx		
.18	x		

It is now necessary to consider the second question as to the interrelationship of the members of groups II and III. Group III may be readily recognized as being made up primarily of the carbon-to-carbon bond distances associated with aromatic ring systems and may thus be said to rep-

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resent a homogeneous group of compounds possessing not only similar bond distances but similar chemical properties as well. Group II is made up predominantly of carbon-to-carbon bonds usually represented as single bonds which occur as part of a conjugated nonaromatic system; for example, the central bond in butadiene, the central carbon-carbon bond in biacetyl, and so forth. In addition, the "single bond" adjacent to an acetylenic linkage in compounds such as methyl acetylene appears in this group. Thus the bonds in Group II form a reasonably homogeneous class with respect to chemical properties as well as to bond distance. The several values falling above 1.56 A are principally derived from measurements of oxalic acid and its salts and may be considered an anomalous group corresponding to a unique chemical composition.

Thus the assumption that has been formulated is not justified by existing data, and the resonance treatment of organic molecules is to this extent logically unsatisfactory. This statement, of course, does not maintain that resonance theory cannot furnish an extremely valuable method for the understanding of organic chemistry, but it raises the possibility of an alternative approach to organic chemical phenomena based on a symbolic system more in accord with physical data. One proposal in this direction has been made by the author (*1*).

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The Paper Chromatography of pH Indicators

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Many types of organic and inorganic substances have already been separated and identified in mixtures by paper chromatography since the separation of amino acids was first described by Consden, Gordon, and Martin (*1*).

During the development of the paper chromatography of the lower fatty acids in the rumen content and blood of ruminants (this will be described separately), it was found of importance to measure the R_F values of the usual pH indicators so as to be able to select a suitable indicator for the determination of the total acids present.

Later, also, the spots of the acids on the chromatogram were shown up by spraying with indicators (*2*), and for quantitative determination by the measurement of spot size it was found best to include the indicator in the solvent so as to get an even concentration on the paper. For this, too, the R_F value of the indicator is of importance, since the indicator should go ahead of the acids to be determined.

There appears to be no reference in the literature that the pH indicators were previously examined by paper chromatography.

The indicators were chromatographed in isopropyl alcohol, butyl alcohol, and amyl alcohol, all containing ammonia, and it was found that many usual mixtures, such as universal indicator, can be readily separated. Also, with only minute quantities of the indicator, it is possible in most cases to determine the identity of an unknown indicator. As additional criterion for an unknown indicator, the color of the spot with acids or alkalies can be observed. Phenolphthalein and thymolphthalein both stay in the colorless form and have to be shown up by spraying the paper with aqueous NaOH solution.

The observation of the colored substances during development may be of theoretical interest, since spot area changes can be studied visually or photographically.

The solvents used were prepared as follows:

Ninety ml of isopropyl alcohol was mixed with 10 ml of 5N NH_4OH; 100 ml of butyl alcohol was shaken with 100 ml of aqueous 1 · 5N NH_4OH, and the top layer used as solvent; 100 ml of amyl alcohol was shaken with 100 ml 1 · 5N NH_4OH, and again the clear top layer was used as the solvent.

The development technique as previously (*3*) is that of Williams and Kirby (*4*), but instead of 5-gal crocks, glass battery jars with fitted glass lids were employed. The lower layers in the case of butyl acid amyl alcohols were placed in beakers and stood on the bottom of the jar, and the top layer was poured on the floor of the jar.

The paper used was Whatman's No. 2, and the indicators were dissolved in ethyl alcohol; spots were placed on the paper and dried before development.

Table 1 gives the R_F values of 16 indicators examined. Isopropyl alcohol is not a suitable solvent, since most indicators travel too fast.

The general trend there appears to be that the R_F

TABLE 1

Indicator	R_F values		
	Isopropyl alcohol	Butyl alcohol	Amyl alcohol
Congo red		0.0	0.0
Indigo carmine	0.0	.0	.0
Chlorphenol red		.17	.01
Phenol red		.18	.01
Cresol red		.41	.12
Brom cresol purple	.68	.43	.10
Brom cresol green	.84	.47	.24
Brom phenol blue		.55	.19
Methyl orange	.77	.55	.26
Methyl red	.73	.59	.33
Neutral red		.66	.53
Brom thymol blue	0.93	.79	.63
Methyl violet	.95	.88	.86
Thymol blue	1.0	.90	.75
Phenol phthalein	1.0	.92	.89
Thymolphthalein	1.0	0.92	0.92

[1] Thanks are due to A. Bryson, of the Sydney Technical College, for gifts of indicators, and to R. L. Reid for criticism and advice.

values decrease with an increase in the number of C atoms in the alcohol, but the R_f difference is by no means constant.

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Oxygen Uptake of Embryonated Eggs Infected with Western Equine Encephalitis Virus[1]

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During the course of an investigation designed to ascertain the effect of virus proliferation on the over-all gaseous exchange of the embryonate egg, it was observed that Newcastle's disease virus (NJ-KD) did not appear to stimulate or suppress the oxygen uptake until near the terminal stage of the experimental infection (*1, 2*). At that time, approximately 40 hr in eggs inoculated with 1,000 MLD, a rapid reduction in the $Q^{s}_{O_2}$ (ml oxygen consumed/egg/hr) to the residual level indicative of infertile eggs occurred. Other investigators, using a group or pool technique, wherein the rates of oxygen consumption were determined not on individual eggs but rather on several in a pool, have reported a primary or initial stimulation in the oxygen uptake shortly after inoculation in the case of *Rickettsia prowazekii mooseri* (*4*) and influenza virus infections (*3*). Further experimental evidence, utilizing other viral agents, was deemed necessary in order to attempt to clarify this question; accordingly, this paper reports the results of a study of the oxygen uptake of individual embryonated eggs infected with Western equine encephalitis virus (WEE).

The reported experiments were conducted with the Olitsky strain of WEE.[3] The strain was initiated by inoculation into 10-day-old eggs and passed twice before use. It titered $10^{-7.5}$ on intracranial inoculation of 0.03 ml into Swiss mice. A 10^{-3} dilution of WEE-infected chick embryo tissue was chosen for the experiments reported here. Normal, uninfected chick embryos of the same age were likewise prepared in a saline suspension (10^{-3}). This embryo suspension served as a control on the possible effects of normal embryo proteins and metabolites on the $Q^{s}_{O_2}$ of the host system—embryonated egg.

[1] This investigation was supported by a research grant from the Division of Research Grants and Fellowships of the National Institutes of Health, U. S. Public Health Service.

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[3] Secured through the courtesy of Charles Armstrong, of the National Institutes of Health.

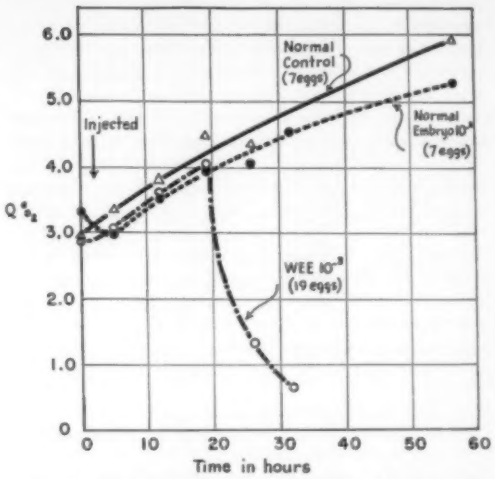

FIG. 1. Mean rates of oxygen consumption of embryonated eggs injected with WEE virus (○), normal chick embryo (●), and of normal control eggs (△).

A number of 10-day-old, trap-nested fertile eggs were divided into 3 lots. One group of 7 eggs served as a control and was not injected. This group provided a reference point against the normal mean $Q^{s}_{O_2}$ as previously established (*1*). A second control group consisted of 7 eggs injected with a 0.1 ml of a 10^{-3} suspension of normal embryo tissue. This control group, as indicated, was used to determine the effect of normal embryo constituents on the metabolic rate of the embryonated egg. A third test group was initiated by injecting 19 eggs with 0.1 ml (10^{-6}) of a chick embryo saline suspension of WEE. The eggs were injected at 4: 00 P.M. of the tenth day of incubation (37.8° C), and the rates of oxygen utilization determined at frequent intervals thereafter until all infected eggs had died, as indicated by their very low rates of respiration. All infected eggs died by the thirty-first hour. The rates of oxygen utilization of 6 eggs of the infected group were determined prior to injection. The postinoculation determinations were run at 3-, 10-, 17-, 24-, and 31-hr intervals. A final reference determination was made on both control groups 55 hr after inoculation.

It was observed that the rates of oxygen utilization of the eggs infected with WEE did not differ significantly from the normal or control series until after the seventeenth hour (Fig. 1). Thereafter, a rapid decline in the $Q^{s}_{O_2}$ of these eggs became apparent. There appeared to be no stimulation of the metabolism of the infected eggs prior to the terminal stage of the infection. This was our experience in every instance on utilizing the described virus. On the other hand, the injection of a normal embryo suspension appeared to suppress slightly the $Q^{s}_{O_2}$. Although this depressed $Q^{s}_{O_2}$ is not valid statistically, it does occur with remarkable regularity.

Data have been presented demonstrating the effect of growth and proliferation of WEE virus on the rates of

oxygen consumption of embryonated eggs. No evidence was obtained indicating that this virus induces a stimulation in the rate of oxygen uptake of such eggs during the course of the infection. Rather, it appeared that the rates of oxygen consumption followed intimately the normal value for embryonated eggs, as well as for eggs injected with an identical suspension of normal chick embryo tissue. Moreover, as the terminal stage of infection was reached, at approximately 17 hr, a marked drop in the $Q^{c}_{O_2}$ occurred. These findings are in accord with our previous observations utilizing the Newcastle's disease virus. It would appear that the growth of the virus in the embryonated egg either does not alter the metabolism until near the terminal stage, or, if the embryo metabolism is altered prior to this period, that a compensating mechanism functions in such a manner that no over-all variation in the $Q^{c}_{O_2}$ becomes apparent.

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The Biosynthesis of 17-Hydroxycorticosterone from 11-Desoxy-17-hydroxycorticosterone

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Following the demonstration by Hechter and his associates (*2*) that desoxycorticosterone was converted into corticosterone when perfused through an isolated beef adrenal gland, Hayano *et al.* (*1*) attempted to repeat the same conversion by incubating desoxycorticosterone or its glucoside with fresh adrenal slices or homogenates. They were able to demonstrate that a substance was formed which exhibited glycogenic activity in the mouse test. Although no isolation of the active component was attempted, it was assumed that oxygen had been added to desoxycorticosterone at the carbon-11 position with the formation of either corticosterone or 11-dehydrocorticosterone.

Employing a technique similar to that described by Hayano *et al.* (*1*), the authors have been able to demonstrate that 11-desoxy-17-hydroxycorticosterone (Reichstein's Compound S) can be converted into 17-hydroxycorticosterone (Kendall's Compound F).

The procedure used in these experiments was as follows: Ten g of beef adrenal gland were finely homogenated with 30 ml of a solution of .01 *M* glucose, 0.062 *M* sodium chloride, 0.02 *M* disodium phosphate, 0.025 *M* potassium chloride, 0.004 *M* magnesium sulfate, and 0.01 *M* sodium fumarate. The homogenate was incubated with 2–10 mg 11-desoxy-17-hydroxycorticosterone (Compound S), added as a fine 0.1% aqueous suspension, for 3 hr at 37° C in an atmosphere of oxygen. Following incubation, proteins were precipitated by the addition of 5 volumes of acetone. The glandular residue was removed and extracted with acetone. Both acetone solutions were combined and the solvent removed by distillation under reduced pressure. Saline was added before the final portion of the acetone was removed. The saline layer was then extracted with chloroform and the chloroform layer concentrated to approximately 1–2 ml. The sample was chromatographed on large sheets of filter paper, using the toluene-propylene glycol system described by Zaffaroni *et al.* (*4*). The sheets were developed for 48–72 hr, sufficiently long to permit good separation of 11-dehydro-17-hydroxycorticosterone and 17-hydroxycorticosterone, both of which are present as bands from chromatograms of extracts of incubated homogenates containing no added Compound S. The locations of the various compounds on the paper were detected by means of ammoniacal silver nitrate reagent and were compared with standard reference strips with Compounds E, F, and S developed at the same time.

The regions containing Compound F were then removed, and the sterol was extracted with chloroform. Upon slow evaporation of the chloroform solution, crystalline material appeared. This was collected and twice recrystallized from chloroform. The final product consisted of fine crystalline needles, which melted at 203°–204° C, with a specific rotation of 157°. The crystals gave the characteristic green fluorescence of Compound F when treated with concentrated sulfuric acid. The physical properties of the crystalline material were compared with a highly purified sample of natural Compound F[1] and found to be almost identical.

The procedure described above resulted in approximately 50% of the added Compound S being converted into Compound F, as determined by the biological activity of the material present in the final chloroform solution. During this process the remaining portion of the Compound S, not accounted for in the formation of Compound F, was converted into other substances that have not as yet been characterized.

Incubation of Compound S with heat-inactivated homogenates or in an atmosphere of nitrogen resulted in no significant conversion of this compound into other substances.

A detailed report of the specific conditions necessary for maximum conversion of Compound S to Compound F and the nature of other products that are formed is now being prepared and will be published elsewhere.

Since this work was completed, Hechter *et al.* (*3*) have shown that Compound S is converted into Compound F by perfusion of the steroid through surviving adrenal glands.

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[1] Kindly supplied by J. J. Pfiffner.

Book Reviews

The Hormones: Chemistry, Physiology, and Applications, Vol. II. Gregory Pincus and Kenneth V. Thimann, Eds. New York: Academic Press, 1950. 782 pp. $12.50.

A number of outstanding endocrinologists have collaborated in preparing this excellent treatise on endocrine physiology. Gregory Pincus discusses the physiology of ovarian hormones. This chapter contains a wealth of information presented in a lucid manner. Unfortunately the author has restricted his review to mammals, with occasional references to experiments on birds. The extremely interesting physiology of ovarian hormones in lower vertebrates is not discussed. R. I. Dorfman has contributed a most valuable chapter on the physiology of androgens. His statement that "head hair, facial hair and pubic hair make up the most striking group which appear to be related to the concentration of circulating androgens" is open to discussion. The growth of pubic and axillary hair is generally considered to be more closely correlated to the androgen level in the blood than the growth of hair on the scalp. The physiology of the adrenal cortex is brought up to date by R. L. Noble. The therapeutic action of cortisone is briefly but adequately discussed.

Two chapters on the physiology of the thyroid, by William T. Salter, give the reader a highly informative and thought-provoking review of this rapidly developing field, including a thorough discussion of the methodology. Both experimental and clinical work are discussed. In spite of the enormous amount of work done in this field, we must agree with the author that "As yet, there is no clear picture of the ultimate function of the thyroid hormone. . . . We know the thyroid hormone's function only by the manifold distortions of metabolism and body structure which characteristically accompany thyroid deficiency or excess of thyroid." Salter classifies the functions of the thyroid hormone under two main headings: the maturity function and the "spendthrift" function. This classification will go far to abolish the widespread misconception that the maturating and calorigenic actions of the thyroid hormone are inseparable.

H. M. Evans and his associates have written the chapters on the anterior pituitary hormones. The Berkeley group has made many important contributions to the physiology of the pituitary and is thus in a position to review the field authoritatively. The results both of clinical studies and of animal experimentation are the basis of this highly readable section. The Australian investigators H. Waring and F. W. Landgrebe have contributed a highly informative chapter on the hormones of the posterior pituitary. This beautifully illustrated chapter gives a complete presentation of the physiology, pharmacology, and biochemistry of posterior lobe extracts.

Chemical control of nervous activity is excellently discussed by D. Nachmansohn, H. Blaschko, and G. H. Parker. In a closing chapter H. Freeman gives a brief summary of the present status of clinical endocrinology. The usefulness of this book as a standard work of reference is enhanced by the excellent index.

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Cosmical Electrodynamics. H. Alfvén. New York: Oxford Univ. Press, 1950. 237 pp. $5.00.

This work is an exploration of the role of electric and magnetic fields in astrophysics and geophysics. It will be valued by all who wish to follow the progress of this recently opened province, as well as by those who are engaged in its study. Coming from Alfvén, whose imaginative investigations have done so much to stimulate thought on these problems, the volume is unquestionably authoritative. It presents both a concise and coherent survey of the requisite background physics and detailed discussions of the various cosmical problems to which the ideas have been applied.

The systematic exposition of Alfvén's theory of magneto-hydrodynamic waves is likely to be especially useful. Chief among the applications are those to solar physics, to magnetic storms and aurorae, and to the cosmic radiation. Ionospheric physics has been excluded. It must be said that some of the applications are decidedly speculative; indeed, the book itself is pioneering in tone. Its very appearance, however, will doubtless prove most influential in advancing knowledge of this potentially highly important field.

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Problems of Morphogenesis in Ciliates: The Kinetosomes in Development, Reproduction and Evolution. André Lwoff. New York: Wiley; London: Chapman & Hall, 1950. 103 pp. $2.50.

This small volume develops, in interesting fashion, the thesis that "morphogenesis of a ciliate is essentially the multiplication, distribution and organization of populations of kinetosomes and of organelles which are the result of their activity." The behavior of basal granules (kinetosomes), and also of the fibrils (kinetodesmas) to which they are joined, is traced through fission and other phases of the life cycle in such genera as *Gymnodinioides*, *Polyspira*, *Phoretophrya*, *Synophrya*, *Lichnophora*, and *Foettingeria*. As clearly shown in these and other ciliates, the basal granule is a self-reproducing element which characteristically gives rise to a cilium. In certain cases a basal granule also may divide into another basal granule and either a "trichocytosome" (trichocyst-granule),

which produces a trichocyst, or a "trichitosome," which gives rise to a trichite.

Both the trichitosome and the trichocytosome may, in at least certain species, reproduce themselves before forming their usual organelles. The basal granule is thus a visible cytoplasmic element which exhibits both polyvalency and genetic continuity, and can give rise to self-duplicating granules with different morphogenetic potencies. Furthermore, the basal granules of one region may differ in behavior from those in another area—an expression of regional differentiation within the body of the ciliate. The multiplication of basal granules, initiating the appearance of two new "morphogenetic fields" in the parental body, typically precedes the more obvious processes in fission. The subsequent organization of the anterior and posterior regions of the adult into two daughter organisms is accompanied by the disappearance of various specialized parental structures.

This general body of facts, to which the author has made extensive contributions, has tempted him into various speculations concerning the significance of basal granules in ontogeny and phylogeny of ciliates. The result is a stimulating series of unanswered questions that will interest protozoologists in general and students of the ciliates in particular.

R. P. HALL

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Scientific Book Register

An Atlas of Human Anatomy. Barry J. Anson. Philadelphia: Saunders, 1950. 518 pp. $11.50.

Morphology and Taxonomy of Fungi. Ernst Athearn Bessey. Philadelphia: Blakiston, 1950. 791 pp. $7.00.

The Private Life of the Protozoa—And of Their Neighbors, the Metazoa and the Insect Larvae. Winifred Duncan. New York: Ronald, 1950. 141 pp. $3.00.

Halloween through Twenty Centuries. Ralph and Adelin Linton. New York: Schuman, 1950. 108 pp. $2.50.

George David Birkhoff: Collected Mathematical Papers, 3 vols. New York: American Mathematical Society, 1950. 2,634 pp. $18.00 the set.

Chemical Embryology. Jean Brachet. Translated from 2nd ed. of "Embryologie Chimique" by Lester G. Barth. New York: Interscience, 1950. 533 pp. $8.00.

Thoracic Surgery. Richard H. Sweet. Philadelphia: Saunders, 1950. 345 pp. $10.00.

Advanced Organic Chemistry. Reynold C. Fuson. New York: Wiley; London: Chapman & Hall, 1950. 669 pp. $8.00.

Response of Physical Systems. John Dezendorf Trimmer. New York: Wiley; London: Chapman & Hall, 1950. 268 pp. $5.00.

Manual of Rice Diseases. G. Watts Padwick. Kew, Surrey, Engl.: Commonwealth Mycological Institute, 1950. 198 pp. $4.50.

Dirichlet's Principle, Conformal Mapping, and Minimal Surfaces. R. Courant. New York: Interscience, 1950. 330 pp. $4.50.

Immortal Magyar: Semmelweis, Conquerer of Childbed Fever. Frank G. Slaughter. New York: Schuman, 1950. 211 pp. $3.50.

Paiute Sorcery. Beatrice Blyth Whiting. New York: Viking Fund, 1950. 110 pp. $1.50.

A Theory of Cross-Spaces. Robert Schatten. Princeton, N. J.: Princeton Univ. Press, 1950. 153 pp. $2.50.

Physiology and Anatomy. 6th ed. Esther M. Greisheimer. Philadelphia: Lippincott, 1950. 841 pp. $4.00.

Nuclear Data: A Collection of Experimental Values of Half-lives, Radiation Energies, Relative Isotopic Abundances, Nuclear Moments, and Cross Sections. Compiled by the National Bureau of Standards Nuclear Data Group. Washington, D. C.: U. S. Government Printing Office, 1950. 309 pp. $4.25 including future supplements.

The Birds of Greenland, Part I. Finn Salomonsen; illustrated by Gitz-Johansen. Copenhagen, Denmark: Einar Munksgaard, 1950. 157 pp. and 17 plates. $9.00.

Introduction to Textile Chemistry. Bruce E. Hartsuch. New York: Wiley, 1950. 413 pp. $4.75.

Giordano Bruno: His Life and Thought. With annotated translation of "On the Infinite Universe and Worlds." Dorothea Waley Singer. New York: Schuman, 1950. 389 pp. $6.00.

A Textbook of Biochemistry. 2nd ed. Philip H. Mitchell. New York: McGraw-Hill, 1950. 695 pp. $6.00.

Linear Integral Equations. Reprint. William Vernon Lovitt. New York: Dover, 1950. 253 pp. $3.50.

TV Installation Techniques. Samuel L. Marshall. New York: Rider, 1950. 330 pp. $3.60.

Plastic and Reconstructive Surgery: A Manual of Management. Ferris Smith. Philadelphia-London: Saunders, 1950. 895 pp. $15.00.

Bertrand Russell: A Pictorial Biography. H. W. Leggett. New York: Philosophical Library, 1950. 78 pp. $3.75.

Techniques in British Surgery. Rodney Maingot, Ed. Philadelphia-London: Saunders, 1950. 733 pp. $15.00.

Swine Production. W. E. Carroll and J. L. Krider. New York: McGraw-Hill, 1950. 498 pp. $5.00.

The Urinary Function of the Kidney. A. V. Wolf. New York: Grune & Stratton, 1950. 363 pp. $7.50.

Annual Reports on the Progress of Chemistry for 1949, Vol. XLVI. R. S. Cahn, Ed. London, Engl.: The Chemical Society, 1950. 333 pp. 25/–.

Industrial Chemicals. W. L. Faith, Donald B. Keyes, and Ronald L. Clark. New York: Wiley; London: Chapman & Hall, 1950. 652 pp. $8.00.

Association Affairs

The Cleveland Meeting

I—*The Annual Science Exposition*

The 117th Meeting of the American Association for the Advancement of Science, to be held in the Public Auditorium and downtown hotels of Cleveland, Ohio, December 26–30, 1950, will be one of the best-balanced in the 102-year history of the Association. Without exception, the seventeen AAAS sections and subsections will hold sessions, which will range in number from three to twelve; societies in the physical, biological, and social sciences will participate; the special sessions will be of the customary high caliber; among the symposia at least two will command international attention—and the Annual Science Exposition, with 150 booths, has now attained a stature consistent with the significance of the entire meeting. As space permits, and as the last details become available, SCIENCE will call attention to the various programs of this Sixth Cleveland Meeting. It is already possible to outline the scope of the exposition, which "... is worth a trip to Cleveland for itself alone."

The AAAS Annual Science Exposition, as an organized activity, may be said to date back to the 79th Meeting, which was held in Washington, D. C., in December, 1924, but there had been exhibitors in preceding years. These included such pioneers as the American Optical Company, Bausch & Lomb Optical Company, Central Scientific Company, Eastman Kodak Company, General Biological Supply House, General Electric Company, and E. Leitz, Inc. —all of them, it is gratifying to report, participants in 1950. Twenty-six years ago the exposition was located in the gymnasium of George Washington University, and arrangements were the responsibility of W. J. Showalter, of the *National Geographic Magazine*. In 1950 the Annual Science Exposition will be housed in one of the finest convention halls in the country, and its general direction has become one of the duties of the Assistant Administrative Secretary of the Association.

An exhibition of the best and latest in scientific books, instruments, and materials, by the firms that produce or distribute such essential aids to science, is an entirely logical adjunct to a scientific meeting, profitable to those who teach and carry on research and an advantage to each exhibitor. It is not merely that the exhibitor makes sales, soon or eventually. He meets his customers, hears the experiences of the consumer of his products, exchanges points of view, and perhaps learns of new needs he may be able to fill. In recent years, the book publishers, instrument makers, microscope manufacturers, and scientific supply houses that are the essential core of the AAAS Annual Science Exposition, have been joined by other nationally prominent industries. Their technical exhibits, which emphasize principles and processes rather than products, make an interesting and welcome addition to the exposition.

Every successful industry has stories of impressive technological accomplishments to tell. A three-dimensional presentation is worth the time and personnel—for a good audience. The thousands of scientists and science teachers who attend an AAAS meeting are keenly interested in both the latest tools of science and the most recent *applications* of science. The industrial exhibits will inevitably demonstrate how inextricably science and technology are interwoven, how dependent the nation is upon enlightened business.

At the 117th Meeting, the Annual Science Exposition will be the largest and most diversified the AAAS has ever held. It will fill the entire street-level arena of Cleveland's Public Auditorium. Exhibitors who will participate are:

MICROSCOPES AND ACCESSORIES

American Optical Company	Buffalo
Bausch & Lomb Optical Co.	Rochester
Bioscope Manufacturing Company	Tulsa
Ercona Corporation (Carl Zeiss, Jena Products)	New York
Gamma Scientific Company	Great Neck
Graf-Apsco Company	Chicago
E. Leitz, Inc.	New York
Rayoscope	Delaware, Ohio

INSTRUMENTS AND LABORATORY APPARATUS

(Other than Microscopes and Accessories)

American Instrument Company, Inc.	Silver Spring
Artisan Guild	Cleveland
Bell & Howell Company	Chicago
Charles Beseler Company	Newark
Brush Development Company	Cleveland
Bussey Products Company	Chicago
Cambridge Instrument Company, Inc.	New York
Cameron Heartometer Company	Chicago
Central Scientific Company	Chicago
Chemical Rubber Co.	Cleveland
Church School Pictures, Inc.	Cleveland
Eastman Kodak Company	Rochester
Hamilton Bell Company, Inc.	Paterson
Harshaw Chemical Company	Cleveland
Hevi Duty Electric Company	Milwaukee
Kelley-Koett Manufacturing Company	Covington
Linguaphone Institute	New York
Microcard Corporation	La Crosse
National Spectrographic Laboratories, Inc.	Cleveland

Nuclear Instrument & Chemical Corporation	Chicago
Phipps & Bird, Inc.	Richmond
Radiation Counter Laboratories, Inc.	Chicago
Radio Corporation of America	Camden
Tracerlab, Inc.	Boston
Victoreen Instrument Company	Cleveland
W. M. Welch Manufacturing Company	Chicago

SCIENTIFIC SUPPLIES

Carolina Biological Supply Company	Elon College, N. C.
Denoyer-Geppert Company	Chicago
General Biological Supply House	Chicago

INDUSTRIAL TECHNICAL EXHIBITS

Allis-Chalmers Manufacturing Company	Milwaukee
American Tobacco Company	Richmond
Cleveland Electric Illuminating Company	Cleveland
Cleveland Graphite Bronze Company	Cleveland
Deering, Milliken Company, Inc.	New York
Eaton Manufacturing Company	Cleveland
Ferro Enamel Corporation	Cleveland
General Electric Company (Lamp Dept.)	Nela Park, Cleveland
General Tire & Rubber Company	Wabash, Ind.
Glidden Company	Cleveland
B. F. Goodrich Company	Akron
Goodyear Tire & Rubber Company, Inc.	Akron
Harris-Seybold Company	Cleveland
Horizons Incorporated	Princeton
Jack & Heintz Precision Industries, Inc.	Cleveland
Merck & Co., Inc.	Rahway, N. J.
Philip Morris & Co., Ltd., Inc.	New York
National Screw & Manufacturing Co.	Cleveland
Nutritional Biochemicals Corp.	Cleveland
Precision Metalsmiths, Inc.	Cleveland
Ralston Purina Company	St. Louis
Remington Rand, Inc.	New York
Standard Oil Company (of Ohio)	Cleveland
Thompson Products, Inc.	Cleveland
Tinnerman Products, Inc.	Cleveland
Warner & Swasey Co.	Cleveland

BOOKS

AAAS	Washington
Academic Press, Inc.	New York
American Book Company	New York
Association of University Presses	Chicago
Biological Abstracts	Philadelphia
Blakiston Company	Philadelphia
Encyclopaedia Britannica	Cleveland
Grune & Stratton, Inc.	New York
Harper & Brothers	New York
D. C. Heath and Company	Boston
Houghton Mifflin Company	Chicago
Instruments Publishing Company, Inc.	Pittsburgh
J. B. Lippincott Company	Philadelphia
Macmillan Company	New York
McGraw-Hill Book Company, Inc.	New York
G. & C. Merriam Company	Springfield, Mass.
C. V. Mosby Company	St. Louis
National Geographic Society	Washington
Oxford University Press, Inc.	New York
Philosophical Library	New York
Prentice-Hall, Inc.	New York
Richard Rimbach Associates	Pittsburgh
Rinehart & Company, Inc.	New York
Ronald Press Company	New York
W. B. Saunders Company	Philadelphia
Science Library	Washington
Science Press	Lancaster
Staples Press, Inc.	New York
D. Van Nostrand Company, Inc.	New York
John Wiley & Sons, Inc.	New York

INSTITUTIONAL EXHIBITS

There is space for several institutional exhibits also. Among those for whom arrangements have been made are:

American Museum of Atomic Energy,	Oak Ridge
Cleveland Health Museum	Cleveland
Fenn College	Cleveland
Special Libraries Association, Cleveland Section	Cleveland

The American Museum of Atomic Energy, which is operated for the Atomic Energy Commission by the Oak Ridge Institute of Nuclear Studies, will show, in a fifty-foot area before the stage: (*a*) the American Chemical Society exhibit on atomic energy; (*b*) the Harrison S. Martland exhibit on radium dial workers; (*c*) a model of the Oak Ridge uranium-graphite nuclear reactor showing radioisotope production; and (*d*) a model of a nuclear energy power plant built by the Brookhaven National Laboratory according to a design proposed by the Monsanto Chemical Company.

RAYMOND L. TAYLOR
Assistant Administrative Secretary

News and Notes

The Fifth International Congress of Microbiology

Ernest Carroll Faust

Division of Parasitology, Tulane University, New Orleans, Louisiana

The congress was held in Rio de Janeiro, Brazil, August 17–24, under the presidency of Olympio da Fonseca, Jr., in commemoration of the 50th anniversary of the founding of Instituto Oswaldo Cruz. The opening plenary session was convened in the Municipal Theatre on the afternoon of August 17, following a morning reception by the Minister of Education and Health, Pedro Calmon, and an early afternoon reception at the Catete Palace by the President of the Republic, General Enrico Gaspar Dutra. All the scientific meetings of the congress took place in the luxuriously appointed Hotel Quitandinha, near Petropólis, which offered excellent private accommodations for the delegates, and adequate room for the 11 sections of the congress to meet simultaneously. There were nearly 500 registered participants, representing most of the Americas, European countries, Iceland, Egypt, South Africa, Israel, Turkey, Iran, India, Goa, and Japan.

Papers were presented in the following sections, each of which held two to four sessions: general microbiology, medical and veterinary bacteriology, rickettsias and rickettsial diseases, mycology, protozoology, viruses and viral diseases, pathogenic microbiology of plants, soil, water, and sewage microbiology, industrial microbiology, immunology and allergy, and classification and nomenclature of microorganisms. In addition, there were late afternoon and after-dinner lectures and conferences on subjects of general interest, such as "Complement and Its Functions," by Michael Heidelberger; "Standardization of Microbiological Tests," led by Geoffrey Rake; "Metabolic Aspects of Bacterial Growth in the Absence of Cell Division," by Walter J. Nickerson; "Le Problème des Bactéries Lysogenes," led by A. Lwoff; "Die Serologie der Enterobacteriaceae," led by F. Kaufurann; "Oswaldo Cruz, Interpretation of a Personality," Clementino Fraga; "Doença de Chagas—Estado Atual do Problêma," A. Vilella; "Control of Rabies," Herald Cox; and "The Identification of *Rickettsia prowazeki* as the Causative Organism of Classical Typhus," H. da Rocha Lima; a symposium on the electron microscope was also held.

On August 22 the entire congress visited Instituto Oswaldo Cruz in the suburbs of Rio de Janeiro and were shown through the various laboratories and clinics. That night the mayor of the city held a reception for the delegates at the Guanabara Palace, where the Ballet of the Municipal Theatre gave an open-air exhibition in the formal gardens of the palace. On two nights there were artistic and musical programs in the theatre of the Hotel Quitandinha, and on Sunday, August 20, excursions to the National Park at Terezopolis and to the Rio Jockey Club. Following the closing of the congress, provisions were made for interested delegates to visit the biological and medical institutions in São Paulo, an hour's air trip from Rio.

The quality of the papers that were presented was good, and discussion indicated sustained interest, but no outstanding new contributions to biology were announced. There was a preponderance of papers in some of the sections by delegates from Brazil and near-by countries, so that considerable emphasis was placed on the pathogenic microorganisms of South America; yet a satisfactory balance was maintained by papers presented in other sections by investigators from Europe and North America. The salient feature of the congress was, perhaps, the opportunity for participants from many countries with diversified interests in the field of microbiology to become acquainted with each other and with one another's problems in so favorable a setting, under one roof, away from the diversions of a large city.

About People

Detlev W. Bronk, president of Johns Hopkins University, and **Rear Admiral Lewis L. Strauss**, president of the Institute for Advanced Study, Princeton, have been appointed to the board of trustees of the Sloan-Kettering Institute for Cancer Research.

Olaf Andreas Hougen, professor of chemical engineering at the University of Wisconsin, will give the second Institute Lecture to the American Institute of Chemical Engineers December 4 at the 43rd annual meeting of the group to be held in Columbus, Ohio, December 3–6. Dr. Hougen will speak on applied kinetics.

Elizabeth Hoyt, professor of economics and sociology at Iowa State College, is traveling under a Fulbright Award to work on a research project that will take her to England and Africa, studying social and economic conditions in certain technologically undeveloped areas in the British Empire. Dr. Hoyt will make her headquarters in Africa at the Institute of Social and Economic Research, Makerere College, Kampola, Uganda.

Stanley A. Tyler, formerly consulting geologist for Jones & Laughlin Iron & Steel Co., has been elected chairman of the University of Wisconsin Geology Department. He succeeds **R. C. Emmons**, department chairman from 1945 to 1950.

Harold K. Schilling, professor and head of the Department of Physics at Pennsylvania State College, has been named dean of the Graduate School, succeeding **Frank D. Kern**, who has retired.

The new director of the National Institutes of Health, U. S. Public Health Service, is **William H. Sebrell**, winner of the Mead Johnson Award of the American Institute of Nutrition and the Research Medal of the Southern Medical Association. During World War II he was co-director, with M. A. Wilson, of the U. S. Department of Agriculture, of the national nutrition program. He succeeds **Rolla E. Dyer**, who has retired.

Milton C. Stuart has been named head of the Department of Mechanical Engineering and acting head of the Department of Industrial Engineering of Lehigh University. Since 1948 he has been acting head of the mechanical engineering staff and becomes acting head of the Industrial Engineering Department following the resignation of **Thomas T. Holme**, now of the Yale faculty.

The chairmanship of the Department of Pharmacology and Materia Medica in the New England College of Pharmacy, Boston, has been accepted by **Nellie P. Watts**, formerly associated with the Department of Radiation Biology, University of Rochester.

Visitors

Emmanuel Fauré-Fremiet, professor at Collège de France, Paris, spoke yesterday at the American Philosophical Society's meeting which closed its sessions today. The subject of Professor Fauré-Fremiet's talk was "Feeding Behavior of Some Carnivorous and Vegetarian Ciliate Infusoria."

Paul Harteck, presiding head of the University of Hamburg and an authority on hydrogen isotopes, will join the staff of Rensselaer Polytechnic Institute on January 1 as visiting research professor of physical chemistry. He will work with the institute a minimum of 18 months. Dr. Harteck's most recent work has been in isolating quantities of tritium.

European speakers at the recent dedication of the new Thomas C. Jenkins Laboratories of Biophysics, The Johns Hopkins University, were **A. V. Hill**, of the Royal Society, London, and **E. D. Adrian**, professor of physiology at Cambridge University, England.

Visiting the National Bureau of Standards recently were **G. J. van der Bie**, director, Indonesian Institute for Rubber Research, Bogor, Java; **F. A. Champion**, in charge of research on corrosion and other surface phenomena at the Research Laboratories of the British Aluminum Co., England; **Geoffrey Gee**, director, **C. M. Blow**, assistant to the director, and **R. Rivlin**, chief physicist, British Rubber Producers' Research Association, Welwyn Garden City, Hertfordshire, England; **Mauro Picone**, director, **Gaetano Fichera**, professor, and **Michele Canepa**, engineer, Istituto Nazionale per le Applicazioni del Calcolo, Rome; **Peter W. Cooke**, chemist, and **Martin M. Strong**, geologist, Anglo-Iranian Oil Co., London; **G. Martin**, superintendent of rubber investigation, Advisory Committee for Rubber Research (Ceylon and Malaya), Imperial Institute, London; and **Frank A. Page**, chief engineer, and **Edward J. Heath**, James Hardie & Co., Sydney, Australia.

Grants and Awards

The Brookings Institution, Washington, D. C., is receiving $60,000 from the **Rockefeller Foundation** to enable it to plan its work on a three-year rather than a two-year basis, and to provide for a major new research program. This research will try to determine the basic interests and foreign policy objectives of the U. S. through a series of comprehensive analyses.

The 1950 **Wellcome Medal and Award** of the Association of Military Surgeons of the U. S. will be awarded to Herman I. Chinn, chief of the Department of Pharmacology at the School of Aviation Medicine, Randolph AFB, Texas, at the annual convention of the association at the Hotel Statler, New York City, November 10. The award is for Dr. Chinn's paper based on studies of motion sickness.

The American Chemical Society's New York section has awarded its **William H. Nichols Medal** for 1951 to Henry Eyring, dean of the University of Utah Graduate School, for his "outstanding contributions to the field of theoretical chemistry, which clarified the theory of rate processes in such diversified fields as chemistry, biology, metallurgy, and physics." The medal will be presented on March 9, 1951.

The 1950 Progress Medal of the Photographic Society of America has been awarded to Loyd A. Jones, head of the Physics Department of Kodak Research Laboratories, for his contributions to photographic science and practice, especially in the field of sensitometry.

The Franklin Institute has awarded the **Franklin Medal** for advancement of knowledge of physical science or its application, to Eugene Paul Wigner, Thomas D. Jones professor of mathematical physics at Princeton University. **Frank P. Brown Medals** have been awarded to Eugene Freyssinet, research and consulting engineer of Paris, and to Gustave P. R. Magnel, of Belgium. Both of these medals were given for contributions to use of prestressed concrete. Russell H. and Sigurd F. Varian, brothers who developed the klystron, were awarded **John Price Wetherill Medals.**

Reinhold Rüdenberg, Gordon McKay Professor of electrical engineering at Harvard University, recently received the gold **Cedergren Medal and Scroll for 1949**, the Swedish award for work in the field of electrical engineering. The medal is awarded every five years by the Royal Governors for the Universities of Technology in Sweden to the most deserving in the arts and sciences of electricity.

C. C. Davis, chief chemist of the Boston Wove Hose and Rubber Com-

pany, received the 1950 **Charles Goodyear Medal** of the American Chemical Society's Division of Rubber Chemistry at the international meeting held October 12–14. Editor of the division's publication *Rubber Chemistry and Technology*, Dr. Davis was cited for his contributions to the literature on rubber chemistry and his leadership as an industrial chemist.

The Department of Preventive Medicine of New York University College of Medicine, a unit of the New York University-Bellevue Medical Center, has received a grant of $10,000 from the Association for the Aid of Crippled Children to continue its study of administrative practices necessary for case finding and follow-up of children with rheumatic fever and heart disease in the Lower East Side district of the city.

American Cyanamid Company has granted 13 postgraduate fellowships and one postdoctoral fellowship in chemistry and chemical engineering for 1950–51. They have been awarded to Carnegie Institute of Technology, University of Colorado, Columbia University, Cornell University, Duke University, University of Illinois, Massachusetts Institute of Technology, University of Michigan, University of Notre Dame, Pennsylvania State College, Princeton University, Purdue University, Stanford University, and University of Wisconsin. Each postgraduate fellowship provides $1,200 for the student, plus $300 or the student's full tuition, whichever is larger. The postdoctoral fellowship carries a stipend of $3,000 for the recipient.

The American Society for Metal's 1950 **Medal for the Advancement of Research** was awarded to Charles E. Wilson, president of General Motors Corporation, during the 32nd annual National Metal Congress and Exposition in Chicago, October 23–27. Mr. Wilson is the eighth distinguished scientist-industrialist to receive the honor, which was established in 1943 to recognize an industrial executive who has consistently sponsored metallurgical research or development and who has helped substantially to advance the arts and sciences related to metals.

The Department of State has awarded Harvey J. Locke, associate professor of sociology at the University of California, a grant-in-aid which will enable him to serve as visiting professor of sociology at the Universities of Uppsala and Stockholm for the academic year 1950–51. Dr. Locke will conduct lecture courses and seminars for graduate students at the two universities, and will assist in the planning and development of a research program for sociologists.

The first 1950–51 fellowship of the **National Paraplegia Foundation** awarded to stimulate medical research in the care and treatment of spinal cord injuries has been awarded to William H. Landau, Washington University School of Medicine. The fellowship was contributed by the Birmingham chapter of the Paralyzed Veterans of America, Van Nuys, Calif.

The Lasker Awards of the American Public Health Association will be presented October 31, during the annual meeting of the association in St. Louis, to George Wells Beadle, professor of biology and chairman of the biology division at the California Institute of Technology; George Papanicolaou, professor at Cornell University Medical College; and Eugene Lindsay Bishop, director of health and safety for the Tennessee Valley Authority. The group award will go to the International Health Division of the Rockefeller Foundation.

The Departments of Medicine and Pediatrics at the University of Tennessee College of Medicine have received two grants totaling $1,900 from the Memphis Chapter of the **American Heart Association**. The Department of Medicine will purchase equipment to improve the facilities for teaching in cardiovascular disease, for aiding the diagnosis and treatment of patients at John Gaston Hospital, and to continue the research projects in cardiovascular disease. The Department of Pediatrics will expand its clinic for children with heart ailments at John Gaston Hospital.

Fellowships and Prizes

Examinations for ten Westinghouse scholarships, totaling $28,500, will be given March 10, 1951, by the College Entrance Examination Board in all parts of the U. S. The scholarships, sponsored annually at Carnegie Institute of Technology by the Westinghouse Educational Foundation, are worth $2,850 each and cover four years' tuition. Competition is open to men who graduate in the upper quarter of their class between January and September, 1951. Application forms may be obtained from the Chairman of Admissions, Carnegie Institute of Technology, Pittsburgh 13, Pa., and must be submitted by *December 1*.

The Life Insurance Medical Research Fund is offering predoctoral fellowships for research in the medical sciences, for 1951–52. These fellowships are open to those who have completed one year or more of work in a medical or graduate school and are in a position to devote at least three-quarters of their time to research. Preference is given to those who wish to work on fundamental problems in cardiovascular function. The usual stipend is at the rate of $1,600–$2,000 per annum. Candidates should be nominated by investigators who are willing to sponsor them on the basis of personal knowledge. The closing date for 1951 nominations is *January 1, 1951*. Further information may be obtained from the Scientific Director of the fund, 2 E. 103d St., New York 29.

The American Dermatological Association is offering a prize of $300 for the best essay submitted of original, unpublished work relative to some fundamental aspect of dermatology or syphilology. Competition is open to scientists generally. The prize-winning candidate may be invited to present his paper before the annual meeting of the association with expenses paid. Manuscripts, together with illustrations, charts, and tables, are to be sub-

mitted in triplicate not later than *February 1, 1951*, to Dr. Louis A. Brunsting, Secretary, American Dermatological Association, 102–110 2nd Ave., S.W., Rochester, Minn.

The American Goiter Association is offering its Van Meter Prize Award of $300 for the best essay concerning original work on problems related to the thyroid gland. The award will be made at the annual meeting of the association in Columbus, Ohio, May 24–26, 1951. Essays may cover either clinical or research investigations and should not exceed 3,000 words. Copies in duplicate should be sent to Dr. George C. Shivers, 100 E. St. Vrain St., Colorado Springs, Colo., not later than *March 1, 1951*.

Meetings

The 22nd annual meeting of the **Society of Rheology** will be held November 3–4 at the Hotel New Yorker in New York City. The program includes papers on the flow of polymers, injection molding, stress measurement, flow of suspensions, and the absolute viscosity of water as a reference standard. The Bingham Medal of the society will be presented to W. F. Fair, Jr., research engineer and supervisor of the Koppers Company Laboratory, for his research in the science and technology of asphalt and his contributions to the development of the society. A West Coast section of the society will hold a separate meeting in Berkeley, Calif., December 1.

A symposium on nutrition fronts in public health will be presented by the Yale University Nutrition Laboratory, in cooperation with the Yale Department of Public Health and the Connecticut State Department of Health, on November 10 in the Brady Memorial Laboratory Auditorium. Papers to be presented are "Diet and Maternal Health," by Icie G. Macy, Research Laboratory of the Children's Fund of Michigan, Detroit; "Factors Conditioning Development of Malnutrition," by Benjamin H. Ershoff, University of Southern California; "Nutrition as a Factor in Aging," by Clive M. McCay, Cornell University; "Influence of Nutrition on Work Performance," by Ernst Simonson, University of Minnesota; "Nutrition and Resistance—Susceptibility to Infection," by Howard A. Schneider, Rockefeller Institute for Medical Research, New York City; and "Nutritional Factors and Hormones in Stress Reactions," by Leo T. Samuels, University of Utah Medical School.

The sixteenth series of **Lectures to the Laity** on medicine and science is being presented by the New York Academy of Medicine at 2 E. 103rd St., and is also being broadcast in the New York area. The Linsly R. Williams Memorial Lecture was given October 25 by Norbert Wiener, of MIT. Forthcoming lectures are: November 15—Hans Selye, "The Renaissance in Endocrinology"; December 6—David M. Levy, "The Relation of Animal Psychology to Psychiatry"; January 17—Paul R. Burkholder, "Quest for Antibiotics"; January 31—Harold G. Wolff, "Life Situations, Emotions, and Bodily Disease"; and February 14—John E. McKeen, "Antibiotics: 'Miracles' Mass Produced."

Colleges and Universities

The University of Pennsylvania will conduct three courses in the diagnosis and treatment of cancer, to be held October 23–November 4, January 22–February 3, 1951, and April 9–21. Each course will consist of lectures, panel discussions, and clinical demonstrations. The Cancer Control Division of the Pennsylvania Department of Health will pay the tuition of each registrant and will provide $200 for living expenses. Application blanks may be obtained from the Secretary, Cancer Commission, University of Pennsylvania, 3400 Spruce St., Philadelphia.

Illinois Institute of Technology is sponsoring a mechanics colloquium, consisting of eight monthly lectures during the present academic year. The meetings, which are free and open to the public, will be held on the campus of the institute, at 8:00 P.M. Speakers and dates are:

Nov. 1—"The Mechanics of Rubber," R. S. Rivlin, the Royal Institution, London.

Dec. 6—"Current Theories of Fatigue of Materials," A. M. Freudenthal, Columbia University.

Jan. 10—"The Buckling Problem from the Standpoint of Dynamics," N. J. Hoff, Polytechnic Institute of Brooklyn.

Feb. 7—"On the Most Effective Way for Producing High Tensile Stresses," M. Hetenyi, Northwestern University.

Mar. 7—"Inverse Solutions of Problems of Applied Mechanics," H. J. Reissner, Polytechnic Institute of Brooklyn. (This lecture will be held at the Technological Institute, Northwestern University.)

Apr. 4—"Vibration Analysis Applied to Engineering Design," N. O. Myklestad, University of Illinois.

May 2—"Recent Developments in the Field of Ultrasonics," R. C. Binder, Purdue University.

L. Landweber, chief of the Hydrodynamics Division, David Taylor Model Basin, Washington, D. C., gave the October 4 lecture.

An instructional program emphasizing nuclear power has been established by **Columbia University's School of Engineering**. The course, Nuclear Power in Reactor Technology, is for qualified graduate students of engineering, mathematics, and the sciences. Several science departments, particularly physics, will participate in the program. Scheduled lecture topics are: "Power Resources of the World," "Nuclear Chemistry and Chemical Physics," "Elements of Nuclear Physics," "Demonstrations in Nuclear Physics," "Metallurgy of Metals in Nuclear Reactors," "Heat Transfer," "Nuclear Reactor Construction," "Stress Analysis," "Power Generation," and "Health Physics."

West Virginia University's new $2,000,000 biology building was opened for use at the beginning of the current semester. The building includes specialized classrooms for laboratory work in plant and animal physiology, biological technique, comparative anatomy, embryology, genetics, bacteriology, and plant pathology, in addition to laboratories for general biology, botany, and zoology. Numerous small libraries, as well as research laboratories, an animal museum, and a herbarium, are provided.

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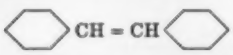
Physicists' chemical . . .



trans-*Stilbene* (Eastman 1817) seems at the moment to interest physicists more than chemists. Its use in scintillation counters is growing fast. In these latter-day successors to the famous Geiger counter, an ionizing particle or photon entering a crystal causes a flash of light which actuates a photomultiplier tube. Stilbene isn't quite as efficient at this as anthracene, but its luminescence decays faster and thus permits better time-resolution in counting. To grow nice, big crystals of *trans*-stilbene the physicists need the highest purity, which is exactly what we give them.

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Ethyl Isocyanide (Eastman 6366) is the odorous constituent present in usual preparations of propionitrile (but not in Eastman's). Now ethyl isocyanide has joined the Eastman list in its own right, neatly illustrating one way the list grows. We've generally synthesized propionitrile five kilos at a time, which left us with a little ethyl isocyanide in the forerun—but not enough to bother with. Recently, however, we filled an order for an unusually large quantity of propionitrile for a large chemical firm. (What they wanted it for we haven't the slightest idea.) That gave us a decent enough slug of ethyl isocyanide to purify *it* and to make it a regular Eastman Organic Chemical.

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CONTENTS *for* NOVEMBER 1950

THE SCIENTIFIC MONTHLY was founded in 1872 as *The Popular Science Monthly*. It has been an official publication of the American Association for the Advancement of Science since 1915. $7.50 per year; special rates to members of the AAAS. For further information, write—AAAS, 1515 Mass. Ave., N.W., Washington 5, D. C.

What GENERAL ELECTRIC People Are Saying

G. B. WARREN

Apparatus Department

GAS TURBINES: For the first time in industrial history gas turbines, a new type of power plant adaptable to land, rail, or marine use, have gone into full-scale production. Orders for more than 20 of the new power plants have already been received by General Electric, for use in power generation and for gas-pipeline pumping stations.

While it is still too early to predict the full potentials of this new power plant, we foresee the increased use of direct fuel-burning power plants like the gas turbine to help meet the country's expanding needs for electric power. Two units, in particular, with ratings of 3500 and 5000 kilowatts, have unique advantages: (1) They are comparatively small and compact, (2) they can be started quickly and require minimum attendance, (3) the smaller unit can be made portable and therefore is well suited for emergency use, (4) both types can be moved easily from the original location to meet changing power needs, (5) they need little or no water, and therefore have special potentialities, particularly in the Southwest, where low-cost gas is available and water is scarce.

Three General Electric gas turbines are already in use. Of these, the first unit to be used in this country for electric power generation has been in regular service more than a year for the Oklahoma Gas & Electric Company in Oklahoma City. A second was put into service last April by a New England power company. Another powers a developmental locomotive built at the Company's Erie Works and now undergoing tests in regular service by the Union Pacific Railroad.

Schenectady, New York
August 15, 1950

★

K. E. WAKEFIELD

General Engineering & Consulting Laboratory

MAGNETIC CLUTCH: Much interest has been evidenced in the National Bureau of Standards' recent report that so-called "magnetic" fluids, consisting of finely divided iron powder mixed with light oil, can be utilized with great efficiency as a medium for binding together two parallel surfaces between which a magnetic field has been produced. Such an arrangement can be readily set up in the form of a clutch and, because of this, the mechanism became known as the "magnetic fluid clutch."

The magnetic fluid clutch consists primarily of two parallel magnetic surfaces separated by a small gap that is filled with a mixture of oil and finely divided iron powder. The surfaces may be two parallel disks or concentric cylinders, each rotating independently of the other about a common axis. The unit contains a coil to produce magnetic flux in the region between the surfaces, and a return path for the flux is provided. Provision is also made to seal in the iron-oil mixture to prevent leakage.

If no magnetic field is present, the force restraining relative motion between the two surfaces is produced only by the viscous drag. In the presence of a magnetic field, however, the fluid seemingly solidifies and the restraining force becomes very great. Thus the device adapts itself well to a clutching or braking operation.

General Electric Review
December, 1949

★

J. P. DITCHMAN

Lamp Department

PLANT LIGHT: The farmer may now control conditions favorable to the growth of plants and animals. Among the farmer's latest implements and agents are new man-made "suns" designed to produce visible radiation, ultraviolet, and infrared radiant energy. These artificial suns may be teamed up with natural daylight or may be used entirely independent of natural conditions. Thus plants may be grown successfully underground in a completely artificial environment of light, humidity, temperature, and air... Our world may in the future depend very much upon how well we learn to apply radiant energy to produce more and better food and to reduce the life processes which oppose our own.

Illuminating Engineering Society
Pasadena, California
August 21, 1950

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3. **Closing Date:** Advertisements must be received by SCIENCE, 1515 Mass. Ave., N.W., Washington 5, D. C., together with advance remittance, positively not later than 14 days preceding date of publication (Friday of every week).

POSITIONS WANTED

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Bacteriologist: Eleven years, supervise vaccine production, allergens. Diagnostic bacteriology, mycology. Biochemistry, body fluids, enzymes, microbiological assay vitamins, foods. Doctorate student. Box 320, SCIENCE. X

Bacteriologist-Biochemist: Ph.D., 32. Desires fundamental research. Experienced physiology, enzymology, pathogenesis. Publications. Box 327, SCIENCE. X

Bacteriologist. Sc.D.; two years, bacteriologist and chemist, large food manufacturing company, eight years' teaching experience, four years as professor and head of department, several years, director, and charge control department of penicillin, biological manufacturing company; for further information, please write Burneice Larson, Science Division, Medical Bureau (Burneice Larson, Director) Palmolive Building, Chicago. X

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Biologist desires teaching or industrial position. M.S. plus. (101 qtr. hrs. Biology, 36 Chemistry) University assisting and Bacteriological experience. Arthur A. Scharf, 5836 N. Keating Avenue, Chicago 30, Illinois. X

Botanist, man 40, distinguished research and teaching record, desires position as head of department. Box 321, SCIENCE. X

Botanist: Ph.D. Columbia University. Desires academic position with research opportunities; experience in experimental morphology, taxonomy, microtechnique. Publications. Available Sept., 1951. Box 322, SCIENCE. X

Librarian: B.S. in L.S., Ph.D. in biology, desires position as Special Librarian or chief in reference, cataloging, classifying or bibliography. Fifteen years library experience in biological and earth sciences. Reading knowledge French, German, Italian, Spanish, Russian. Box 323, SCIENCE. X

Pharmacologist, M.D., medical school instructor, two years. Want academic position in medical, dental or pharmacy school. Interested cancer research. Box 328, SCIENCE. X

Radiochemist: B.Sc. plus graduate training. 10 years experience includes analytical, physico-chemical, radiochemical and nucleonics research and development. Proven versatile ability to administer, supervise and carry out energetically independent investigations in numerous fields requiring imagination and flexibility. Box 324, SCIENCE. X

Personnel Placement

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Assistant to Research Director—Small proprietory pharmaceutical house has opening for Assistant Research Director. Experience in pharmaceutical chemistry and allied fields preferred. Specific experience with dentifrices desired. Plant located Metropolitan New York area. Replies held confidential. Box 329, SCIENCE. X

Histological Technician: Thoroughly experienced in paraffin and celloidin methods. American Meat Institute Foundation, The University of Chicago, 939 East 57th Street, Chicago 37. R11/3

Positions Open:
(a) Biochemist, Ph.D., interested in immunology; duties include supervising preparation of allergy extracts, extensive research; East. **(b) Pharmacologist** to divide time between directing research division, pharmaceutical company, and serving as professor pharmacology in medical college; Ph.D. or M.D.; competent administrator with teaching ability required. **(c) Assistant director,** medical department, export division, pharmaceutical company; duties include literary research, clinical investigation; frequent trips to South America; knowledge of Spanish desirable; headquarters: East. **(d) Physiologist and biophysicist,** supervisory appointments; should be qualified to direct research programs involving effects of radiation on endocrines; Ph.D.'s required; medical degrees advantageous; West. **(e) Bacteriologist or serologist,** Ph.D. to supervise blood bank and departments of bacteriology and serology, general voluntary hospital, fairly large size; minimum $6,000; California. S10-4 Science Division, Medical Bureau (Burneice Larson, Director) Palmolive Building, Chicago. X

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At the 1949 Meeting, the Council of the AAAS voted overwhelmingly to continue Advance Registration. To insure its prompt receipt, the General Program will be sent by *first class mail* December 1–4, 1950—which is also the *closing date* for Advance Registration.

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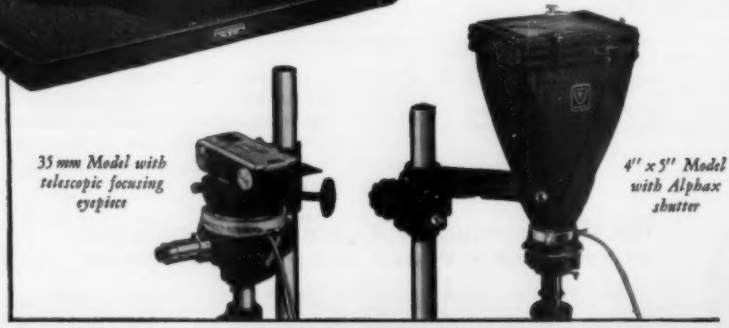

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